LAND CONDITIONS IN VENEZUELA AND THEIR RELATIONS TO AGRICULTURE AND HUMAN WELFARE

by

SOIL CONSERVATION MISSION TO VENEZUELA

from

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

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INTRODUCTION

The United States Soil Conservation Mission went to Venezuela in response to a request transmitted by the Venezuelan Minister to the United States, on October 21, 1940. This request proposed to Secretary of State, United States of North America, that Hugh H. Bennett, Chief of the Soil Conservation Service, Department of Agriculture, together with required assistants, go to Venezuela for the purpose of preparing an action program for the conservation of soil and water resources of that country. The following letter contains the proposal:

October 21, 1940

His Excellency Cordell Hull
Secretary of State of the
United States of America
Washington, D. C.

Sir:

I have the honor to inform Your Excellency that my Government is very much interested in obtaining the services of Dr. Hugh H. Bennett, Director of the Soil Conservation Division of the Department of Agriculture, who, as per previous exchange of views between the Ministry of Agriculture of Venezuela and the Agricultural Division of the Pan-American Union, would be willing to visit my country with one or two of his assistants in order to organize the preliminary work and sketch a plan of action for the conservation of the soil and water resources, and the adoption of certain types of planting to the climate and to the physical condition of the soil.

In view of present circumstances, the Ministry of Agriculture of Venezuela is especially interested in finding out what would be the approximate cost to my Government of the contemplated trip of Dr. Bennett and his assistants, and I beg to request your kind cooperation in furnishing me with this data, in case that the trip of the Commission can be arranged through the courtesy of the Department of Agriculture of the United States.

I avail myself of this opportunity to renew to Your Excellency the assurances of my highest consideration.

/s/ Diogenes Escalante.

As a result of the request, arrangements were made for a Soil Conservation Mission to go to Venezuela. This Mission was authorized by the President of the United States, under provisions of the Act of May 3, 1939 (Public 63, 76th Congress). This was composed of four men from the Department of Agriculture: Hugh H. Bennett, Chief, Soil Conservation Service; Donald S. Hubbell, Soil Conservationist; William X. Hull, Agricultural Engineer; and James E. Caudle, Soil Scientist. The party sailed from New York on December 5 and arrived at Caracas,

December 11, 1941. Bennett returned to the United States on January 29, 1942, and the last member of the party got back on June 6, 1942.

Soon after the arrival in Caracas, the Minister of Agriculture, Mr. Rodolfo Rojas, introduced the members of the Mission to the Venezuelan technicians whom he had selected to work with the United States party in connection with any surveys, investigations, or demonstrations to be made. These were: Juan Manuel de la Cabada, Agronomist; Jose Antonio Rugeles, Horticulturist; Miguel Parra Pensini, Forester-Engineer; Vincente J. Carvajal, Economist; Gustavo Tejera, Soil Specialist; Eduardo Palacios Blanco, Soil Specialist; and Rafael Jimenez Macias, Economist. The first three men accompanied the Mission during all of its work; and others at various times. Later four agricultural students were detailed to work with the Mission at various times: Oscar Villanueva, Julio Montenegro, Jesus Contreras, and Ricardo Jahn.

At this first meeting with the Minister, general plans for carrying on the work were outlined. Among other things, the Mission was urged to carry its work into the demonstration stage, following completion of the basic investigations, in order to show the Venezuelan agricultural technicians, farmers, and others how to apply to the land the various adaptable methods for controlling erosion, conserving rainfall, and improving land use.

In order to study the land and agriculture of the country and to determine what could be done in a practical way to improve any unfavorable conditions that might be found, particularly as relating to land conditions, soil erosion, and loss of rainfall, the group of conservation specialists made a number of trips through the mountainous areas and lowlands of northern Venezuela and through various parts of the Llanos as far south as Ciudad Bolivar on the Orinoco. Nearly a month was spent examining the mountainous area between Caracas and the Colombian border. Several trips were made into Llanos, from the headwaters of the Uribante River, near the Colombian frontier to Cumaná on the Caribbean. Finally the coastal lowlands and hill sections of the State of Falcón and the lowlands and enclosing foothills of the Lake Maracaibo Basin region were investigated in a reconnaissance manner.

Field work was started December 13, 1941. From then until the end of May the greater part of the time was spent in travel and on demonstrational work in various localities.

Having ascertained the predominant conditions with respect to the land and its use, the Conservation Mission devoted several weeks to the application of conservation practices as demonstrations, on various tracts of representative types of farm land. Field terraces were built and contour tillage systems installed on several private farms near Maracay. Plans were developed for the improvement of irrigation practices and for soil and water conservation work for a plantation near Turmero, in the State of Aragua. Terraces were built at the San Felipe Experiment Station, in Yaracuy, and lines were laid out for the installation of strip cropping and for permanent grass strips. Also, a farm cropping plan was developed for the Station. At Barquisimeto, in the dry country, contour furrows were installed on a large area from which livestock were excluded. Near Mucuchies, State of Mérida, a complete terrace system was constructed, contour furrows were plowed out, check dams for gully control were built, and trees and grasses were planted on land needing cover. At Mérida lines for installing strip cropping were run out on several private farms, and appropriate cropping systems were developed for each of these.

In order that all technicians assigned to the party might become thoroughly acquainted with Venezuela's land problems and the development of an adaptable program of soil and water conservation, the Soil Conservation Mission encouraged continuing observations and daily discussions of land-use practices and the effects of erosion -- somewhat on the basis of a traveling conference. There were discussions -- and sometimes spirited arguments -- in the field, while traveling along roads, and in the evenings at hotels.

At all times splendid cooperation was received from the Minister of Agriculture and the members of his technical staff. Helpful assistance and encouragement were also given by the various State Governments and by some of the schools and colleges. The United States Ambassador, the Honorable Frank P. Corrigan, and his staff were very helpful and cooperative at all times. Farmers in those areas where demonstrations were carried out showed the keenest interest in the work. "Field days" spent in studying the problems of erosion and methods of control were well attended by farmers of the localities.

Because of war conditions, police regulations and restrictions were greatly intensified throughout the Republic, but in spite of this the Soil Conservation Mission was afforded every courtesy by the Department of Security. Members were given special passes, and at no time or place were they hindered in any way in their travel or work.

In the following chapters the various major land types, the principal soils, and the climate are discussed, and their relation to agricultural operations is briefly explained. Special emphasis is devoted to such problems as soil depletion by erosion, the effects of overgrazing and continuous cropping, practical soil and water conservation, irrigation, resettlement, conditions of vegetation, and human circumstances.

Map 1 shows the itinerary of the Conservation Mission. It does not show, however, the numerous side trips made on foot or horseback.

METHOD OF APPROACH

In order to present any worthwhile suggestions or recommendations with respect to ways and means for bettering conditions on the land, it was decided to see as much of the principal agricultural sections of the country as possible, as quickly as possible. Accordingly, trips were made over most of the country north of the Apure-Orinoco drainage. All the principal kinds of lands encountered were carefully inspected as to predominant slope, soil, degree of erosion, susceptibility to erosion, vegetation, climate, and general suitability to agriculture, including grazing and forestry.

These studies covered investigations of conditions on the ground -- that is, direct studies (in no way related to second-hand information). For example, the character of the soil, the slope, crop yields, degree of erosion, condition of vegetation, farm income, etc., were determined through actual visits by automobile, horseback, and on foot to fields, ranches, and abandoned areas. Farmers of all classes were consulted and from them were obtained measured or estimated yields, the amount of their income, and their opinions with respect to the future of Venezuela's agriculture, as well as their individual needs and outlook. Samples of the principal soils were collected, slopes were measured, the vegetative composition of both virgin and second growth was examined, and prevailing methods of farm and ranch practices were ascertained.

In the following pages the results of these studies are presented in some detail, along with general recommendations for betterment of conditions.

After becoming acquainted with the principal land problems, especially with respect to the exceedingly serious problems of soil impoverishment by erosion, wastage of rainfall, and consequent deficiencies in water supplies, considerable work, as noted above, was carried out in a number of localities to demonstrate some of the more effective practical farm and ranch methods that have been employed in the United States and elsewhere for the amelioration of various aspects of these problems.[1/]

1/ See Soils and Security, Bennett, H. H. Soil Conservation Service, U. S. Dept. of Agriculture; and Soil Conservation, Bennett, H. H. (McGraw-Hill Book Company) New York.

NORTHERN HIGHLANDS

The term Northern Highlands is used to cover that portion of the mountainous country which begins near the eastern end of the Western Highlands in the vicinity of El Tocuyo, in the State of Lara, and extends along the Coast to the Gulf of Paria.

The Northern Highland area, in reality, is a continuation of the Western Highlands, but with lower altitudes and a higher proportion of land of less rugged topography.

Topography: Beginning about 25 miles west of Valencia, these north coast mountains divide into two roughly parallel ranges separated by (1) the Lake Valencia Basin and the tributary Aragua River Valley, and (2) the valley of the Tuy. The trough between the two ranges is broken only by a transverse highland area representing the drainage divide between the headwaters of the Aragua and the Tuy near El Consejo.

The northerly range is generally higher and more rugged. It rises abruptly from the Caribbean Sea to 7,373 feet above sea level in the vicinity of La Mesa in the State of Aragua within a distance of 9 miles, and to a height of 9,069 feet within a distance of 4 to 5 miles in the Avila range northeast of Caracas. This northerly part of the Northern Highlands extends easterly along the coast and terminates at Cabo Codera on the Caribbean Sea.

Drainage: Drainage for the most part consists of many short, turbulent wet weather mountain streams, flowing from the crest of the range northward into the Caribbean Sea and southward into Lake Valencia or into tributaries of the Tuy River. These short streams in many cases are very active, carrying much silt during the rainy season and becoming perfectly dry during the dry season. Exceptions are four tributaries of the Tuy, namely; the Guaire, flowing through the Caracas Valley; the Caucagua, rising east of Petare and joining the Tuy near Caucagua; and the Merecure-Urapo and the Capaya still farther east.

The southerly range is broader than its parallel coastal associate on the north; is generally less rugged, and is of lower elevation. It extends eastward, with an average elevation of about 3,500 to 4,000 feet and a maximum elevation of 5,000 feet south of Caucagua. It touches the coast at Boca de Uchire, and continues eastward along the sea to Guanta, though greatly reduced in elevation, averaging less than 1,000 feet. This lower section is really a range of low, rounded hills.

Rising again from this stretch of hills, the range continues eastward to the eastern extremity of the Peninsula de Paria, with an average elevation of about 4,000 feet and a maximum of about 8,300 feet on Cumanacoa Peak.

This southerly range from its beginning west of Valencia to Boca de Uchire is generally steeper on the north-facing slopes, and the streams are all short and swift (especially during the rainy season), flowing either into the Tuy River or Lake Valencia. South of the crest, the range is much broader and less rugged. Many streams which cross the Llanos and empty into the Orinoco have their headwaters here. Among them are the Chirgua, Tiznados, Guárico, Orituco, and Pao Viejo.

In the hills between Boca de Uchire and Guanta the drainages are chiefly short quebradas that contain no flow of water during the greater part of the dry season. These hills are also cut by the Unare and Aragua which drain portions of the Llanos. These are not, properly speaking, a part of the mountain drainage system.

Eastward from these hills the mountains are similar to the other portions of

the southerly range to the west. Not more than about 15 percent of the total mountain area east of Santa Inés is excessively steep or rugged. However, other large areas are virtually useless for agriculture or grazing because of excessive erosion or low rainfall.

The higher, more rugged section is that near the center of the range, where the drainage pattern is roughly radial. The San Juan River flows in a generally easterly direction. Many smaller streams flow southward to join the Guarapiche, the Tonoro, or the Amana, which flow easterly to the Gulf of Paria. In a westerly direction flow the Neveri River and several tributaries of the Aragua. To the north the Manzanares, with its tributaries, is the main drainage. Many intermittent streams or quebradas also flow northward through the drier mountain country.

That part of the Northern Highlands between El Tocuyo and the Lake Valencia area, where the range splits, is topographically similar to the southerly sector of the range and in further discussion will be included with it.

From this western area, two main rivers, the Tocuyo and the Yaracuy, drain northward. From the southerly slope flow the Portuguesa, Guache, Acarigua, Duragua, Tirgua, Tinaco, and many others, all of which eventually reach the Orinoco. One River, the Turbio, rising southwest of Barquisimeto and flowing northeastward, swings southward through a low pass southeast of that town to enter the Cojedes. The latter continues to the Orinoco.

Agricultural Lands: The most successful farming operations of the region are carried on in the Valencia Lake Basin and in the valleys of the Turbio, Yaracuy, and Tuy Rivers and their tributaries, where an important part of the better agricultural lands is found.

Of the total mountain area between the vicinity of El Tocuyo and Boca de Uchire about 8 to 10 percent is alluvial (first bottom and terrace). Of this, only about half is in cultivation (including pasture) at the present time.

Cultivation on the mountain slopes varies considerably from one locality to another because of steepness of slope, amount and distribution of rainfall, depth of soil, degree of erosion, and, to a limited degree, accessibility to markets. For example: Along the highway from Caracas to Los Teques only about 1 percent of the land is in cultivation; whereas, in the immediate vicinity of Los Teques about 40 percent is cultivated and along the Caucagua river from Colonia Tovar to Caucagua about 20 percent is cultivated.

Probably about 15 percent of the total mountain area is cultivated. These mountain slopes, plus the alluvial areas, give an estimated total cultivated area of about 20 percent of the Northern Highlands.

Vegetation: Vegetation is somewhat varied owing to elevation, rainfall, erosion, and land use. A few remnants of the virgin forest remain. The largest extends from near the summit of the mountains north of Maracay almost to the sea and westward to a point south of Taria in the State of Carabobo.

Large areas are covered by a savanna type of vegetation, chiefly in the southerly range and in that part of the northerly range around Lake Valencia. Most of the remainder is covered with grass and rastrojo in various stages of growth.

In the vicinity of El Valle and on the badly eroded slopes between Caracas and La Guaira a semi-desert type of vegetation is found, consisting largely of cují and cactus. This latter type of vegetation has invaded this originally forested section largely as the result of erosion. According to Dr. H. Pittier, cactus was not found in the hills around El Valle (where he lives) even as recently as 1913. Today it grows extensively.

Eastward from Boca de Uchire to Santa Inés, where the elevation averages less than 1,000 feet, the vegetation consists of dry-forest, and there is practically no farming. But to the east of Santa Inés considerable cultivation is carried on.

Land use and erosion: In the few remaining areas of the virgin type of forest the soil mantle is intact, just as nature made it. It is friable and absorptive of the rains. Live streams flow from these heavily forested lands, with clear water that runs on after the rains. But on the cultivated (and once cultivated) and repeatedly burned-over mountain slopes the situation is very different. Practices of improper cultivation: Plowing up and down the hill, continuous cultivation without rotation, and the burning of crop residues and firing of rastrojo have had serious consequences. Destructive erosion thus initiated, has continued from year to year until large areas have been made useless for cultivation. Other areas have been so impoverished of plant nutrients by continuous cropping without return of organic matter, animal manures, or commercial fertilizer that they, along with the eroded lands, have either been abandoned to rastrojo or are still being cultivated through a process of clearing - abandonment - reclearing, with constantly diminishing returns.

The yields on these eroded and abused mountain lands, of both the Western and Northern Highlands, have in many instances run down to meager amounts, often as low as 2 to 5 bushels of corn per acre.

Extremely serious consequences are human impoverishment -- sometimes, as in all severely eroded lands throughout the world, to the point where the people who try to live by the fruit of the land get so little for their efforts that they do not have even sufficient gross food or the means for getting sufficient food.

And, further, the former friable and highly absorptive forest lands, stripped of the absorptive topsoil down to hard clay or rock, now shed the rainfall too rapidly. This floods the streams with soil-laden waters, and insufficient water for favorable plant growth is left behind in the soil. Accordingly, a near desert condition replaces the once highly favorable humid condition that supported magnificent forests, produced good crops when the land was newly cleared, and kept the springs and streams alive.

WESTERN HIGHLANDS

For convenience of discussion the term Western Highlands is employed in this report to cover that part of Venezuela in the mountainous area lying to the southwest of Carora. Most of this area lies in the States of Lara, Trujillo, Mérida, Táchira, Barinas, Portuguesa and Cojedes. This chain of highlands is commonly known in Venezuela as Los Andes. It is shown on the map of the Americas recently published by the American Geographical Society of New York as Cordillera Oriental. Some geographers have referred to the region as the Sierra Nevada Mérida.

At any rate the area is a northeasterly projection or fork of the Cordillera Oriental or eastern branch of the Andes Range. It extends from southwestern Colombia to the vicinity of El Tocuyo, Venezuela. (The northerly projection of the Andes, extending along the Venezuela-Colombia boundary west of Lake Maracaibo, was not examined in any detail and for that reason is not treated in this discussion.)

This northeasterly projection of the eastern range of the Andes is partially separated from the coastal range east of Barquisimeto by the hill and basin country of the State of Lara.

Topography: It is, in its major development, a lofty mountain range that rises abruptly from the low coastal plain of Lake Maracaibo on the north and from the flat plains country -- the Llanos -- on the south. Pico Bolívar, a dominating

peak some 10 miles southeast of Merida, is shown on some maps as having an elevation of 16,406 feet above sea level. Portions of the summit are permanently snow-covered. What is more important from the point of view of land use is the steepness of the prevailing slopes within those accessible locations of more favorable rainfall.

Since the lands of the Andes vary from flat stream plains to vertical cliffs, every conceivable degree of slope declivity comes in between. Some conception of the steepness to which much of the land ranges can be gained from consideration of the fact that this lofty range rises abruptly along much of its exterior boundaries from low practically flat plains on both sides to culminating elevations ranging in different sections of the mountain chains or groups from around 3,000 to more than 16,000 feet. The line of contact with the southerly plains (the Llanos) is, according to elevations given on available maps, approximately 600 to 700 feet above sea level, while the contact with the plains bordering Lake Maracaibo on the northerly side of the range is in the neighborhood of 500 feet above sea level. With respect to the broad area of intermingled hills, ridges, mountains, valleys, benches, and plains separating the Andes from the Caribbean Sea, the line of division is not so well defined. This lower country that characterizes so much of the State of Falcón might be said to contact the Andean Highlands approximately along the 2,000-foot contour line on the south side of the drainage basins of the Baragua, upper Tocuyo, and Carache Rivers.

A fairly representative cross-section of the high Andes is the 68-mile line extending from the 500-foot contour line near Palmarito in the State of Zulia to the 500-foot line near Pedraza (Ciudad Bolivia) in the State of Barinas. Along this line the elevation ranges up to approximately 13,507 feet on the crest of Páramo Mucuchies, near the center of the traverse. Such generalized statements of maximum and minimum elevation do not convey a clear conception of the important aspects of the regional topography. The important aspects of the topography, as relating to land use, are the topographic details.

What is important here is that the country is made up of cliffs, flat stream bottoms and benches, shouldering positions and extraordinary steep mountain sides along with some moderate and gentle slopes.

A somewhat better conception of the gradient of some of the steeper areas is gained from the rise of 8,500 feet in a distance of 8 miles from the center of the valley of the Upper Tormero River, near Timotes, to the crest of the Páramo to the west -- Mucuchies. Here the average slope declivity is about 53 percent. Even this doesn't mean a great deal, because of the presence of more or less flattish shouldering positions and the relatively gentle slopes that occur here and there. Many places within this steep mountain country have a declivity of 100 percent.

From the practical point of view the slopes of measured fields mean much more than any averages worked out from the very rough topographic maps available. These measurements indicate that around 30 percent of the cultivated land of the Andes has slopes that range from about 1 to 30 percent; about 15 percent, from 30 to 40 percent; about 40 percent, from 40 to 70 percent; and about 15 percent, steeper than 70 percent.

Some of the broad land classes include areas much steeper than these roughly estimated averages, and others comprise more gently sloping area. For example, it is estimated that 30 to 50 percent of the area classed as Very Steep Mountain Land consists of cliffs and near-cliff areas, while the San Cristóbal Basin type includes around 50 to 60 percent of land that is favorable, from the slope standpoint, to agriculture -- that is, that much of this relatively smooth country in the State of Táchira has a slope of not more than about 30 or 35 percent. Additional stony areas that can be cultivated on steep slopes will bring the percentage of land suitable for cultivation up to about 65 to 75 percent of the total San Cristóbal Basin.

Drainage: The area of densest population -- the most dense of the entire country -- is a succession of interior axial valleys traversed by the Caracas-Bogotá Highway, together with a considerable number of the tributary valleys and some disconnected mountain valleys.

From Carora, in the western part of Lara, this roughly defined succession of axial valleys follows the courses of the Bucares, Carache, Motatán (Tormero in the upper part), Chama, Mocoties, Quebrada Venecara, La Grita, and the Torbes down to the village of Tariba where the valley widens out into the San Cristóbal Basin. These several valleys roughly paralleling the general direction of the Venezuelan branch of the Andes are separated by passes or drainage divides such as: (1) the pass from the headwaters of the Bucares to the headwaters of the Carache (near Cerro Gordo, elevation 3,542 feet); (2) from the headwaters of the Motatán -- Tomero drainage to that of the Chama (by Páramo Mucuchies, elevation indicated as something above 13,500 feet); (3) the divide between the Mocoties and Quebrada Venecara (by Páramo Negro, a little below its lower limits, elevation of probably about 10,000 feet); and (4) the divide between the Grita and Torbes (by Páramo Zumbador, at an elevation of something over 10,000 feet).

Most of the streams traversing the valley floors are bordered by strips of flat or billowy (undulating or hummocky) alluvial soil (first bottom or bench-land -- terrace -- or both), most of which is in cultivation. Some of the valley floors rise gradually to high elevations, as, for example, the more or less rounded floor of the headwaters of the Chama River which highland valley holds to some approximation of a flat-floored valley up to an elevation of nearly 11,000 feet, above the village of Apartaderos. Practically all of these relatively smooth lands are cultivated, with or without irrigation. Even those alluvial areas where stones are so abundant that hand cultivation is necessary are used for crops. In some low rainfall localities certain areas for which irrigation water is not available are utilized for pasture. Here and there are relatively small areas of imperfectly drained land, such as those seen in places along Torbes River south of San Cristóbal. These are used only for pasture.

The older alluvium, occuring on terraces and remnants of terraces that are almost as common as the recent alluvium (first bottoms) for long distances along many streams, is nearly as extensively cultivated as the lower bottoms, even where old erosion (geological erosion) has carved the former flat-topped lands into a hillocky or lumpy surface configuration. Some of these older benches rise to several hundred feet above the beds of the streams, but most of the frequent sharp slopes that separate them from the low bottoms are farmed -- plowed crops on the gentler escarpments and hand-tilled crops where declivity makes it impossible or impracticable to plow.

Agricultural lands: As well as can be determined, the alluvial bottoms and benches -- the best agricultural lands, generally -- collectively comprise not more than about 3 or 4 percent of the mountain area proper.

The entire cultivated portion of the mountain area (all cropped lands, not counting range lands, but including pasture lands -- pastos) appears to amount to about 18 or 20 percent of the whole mountain area. In some localities, with steep enclosing highlands, around 75 percent of the land is cultivated as, for example, in the immediate vicinity of La Grita in the State of Táchira. But such situations are exceptional.

After the alluvial areas, the most favorable lands are the shelving or shouldering positions and smoother portions of the valley slopes. These lands rise above the stream bottoms and benches often to thousands of feet, in some instances up to the border of the páramos (the lower limits of which seem to be around 11,000 feet above sea level). Wheat culture, for example, practically touches the lower limits of Páramo Mucuchies in places (elevation in the neighborhood of 11,000 feet). These relatively smooth mountain slopes are collectively

more extensive than the bottomlands and associated terraces. It is estimated that the more favorable lands for cultivation in the Andes area (bottoms, benches, shelving positions, and gentle slopes) amount to about 8 percent of the total area or about 40 percent of the cultivated area.

The 18 to 20 percent estimate of cultivated land is more likely to be high rather than low. It must be remembered that this Andean area is a major mountain mass that comprises numerous cliffs and near-cliffs, narrow canyons, rock outcrops, and a very considerable area of savanna hill country almost entirely unfit for cultivation because of shallow soil, stoniness, and droughtiness. Moreover, a very considerable amount of land that once was cultivated has been stripped of productive soil by sheet erosion or slashed to pieces by gullying. And still other areas have been so reduced in productivity that the land has either been abandoned or remains under rastrojo (second, third, fourth growth, etc.) for long periods -- 5 years, 10 years, 15 years, or longer. Rastrojo was not included in the estimate above. Most of it is too steep or has suffered too severely from generations of cultivation without protection from erosion and without replenishment in any manner of plant food constituents removed by cropping and erosion.

The remaining area of cultivated land in the Andean uplands rated as below the level of fair to good farm land (estimated as 60 percent of all the cultivated land) is so appraised because of: (1) steepness of slope, (2) shallowness or other undesirable soil characteristics, (3) low rainfall, (4) erosion and soil depletion by cropping, and (5) excessive loss of rainfall by runoff.

This sequence of productivity ratings does not give a completely accurate appraisal of the land for purposes of cultivation, because the indicated order of favorability for farming overlaps in some degree. Slope declivity, for example, often, perhaps usually, is a factor of unfavorableness as much because of its relation to the hazards of erosion and rapid loss of water by runoff as because of difficulties of cultivation and transportation on such steep lands.

Land use and erosion: While the kind of soil and the use made of the land have much to do in determining the degree of declivity on which farming operations can be conducted with safety, cultivation of slopes steeper than about 25 to 30 percent generally should not be carried on under prevailing practices of continuous clean tillage regardless of soil quality other than that of stoniness. Even these lands of lower declivity will need the protection afforded by such practices, or combination of practices, as contour cultivation, terracing, strip cropping, soil-improving rotations, and surface utilization of crop residues (as a mulch). There is no other way either of preventing impoverishing and destructive erosion or of avoiding soil exhaustion. Here, as in other parts of the world, where slopes of ordinary land are used for the clean-tilled crops, that land ordinarily should be cultivated on the contour if steeper than about 1 to 3 percent. If the fields are so stony that rainfall is rapidly absorbed, cultivation can, of course, be carried on safely on much steeper gradients. As a matter of fact, many fields so stony that only hand cultivation was practicable were seen where corn, yuca, bananas, wheat, and potatoes were safely produced on slopes exceeding 50 percent, and in some instances on slopes up to around 70 or 75 percent. And, of course, when the land is used for grass and good stands are maintained by reason of sound grazing practices, areas much steeper than 35 percent can be used without initiating serious erosion. If permitted to grow up to forest, naturally or by planting, erosion can be controlled, when not grazed or frequently burned, on slopes of around 100 percent (not degrees).

Impoverishing and destructive soil erosion is, in the practical sense, very nearly synonomous in the Andes with excessive loss of rainfall by runoff, since most of the damage is done by water rather than by wind. And, accordingly, the steeper the land, the cleaner it is stripped of protective vegetation: and the straighter the furrows of plows are directed downhill, the greater is the runoff. And the greater the runoff, the faster the soil is swept into the rivers. And it

is under these conditions that flood hazards are increased and springs and wells and streams run low or dry up.

Other ill consequences that go along with accelerated erosion are loss of water during rainy seasons that should be stored in the land to nourish crops in times of drought, to keep springs and wells filled with water, and to keep the rivers running permanently instead of flooding at one season and carrying no water at other times.

Many dry streams were seen, even in the early part of the dry season -- in December -- where there was evidence of former permanent flow, both physical and historical.

By burning or removing every vestige of vegetation from fields -- as corn stalks, the vines of peas, the stubble of wheat, the refuse of new clearings -- the soil is laid bare to excessive washing and to depletion of the life-giving vegetable matter -- humus -- that productive lands require. The sun dries the soil almost to the hardness of stone in the dry season, moisture is dissipated by evaporation, and the beneficial soil forms of life, as earthworms, bacteria, and molds, become relatively inactive. These unfavorable conditions -- most of which could be avoided, as will be pointed out -- bring the soil to a condition of temporary or seasonal dormancy that is probably harmful to the productive capacity of the land.

The effects of dry climatic conditions are such that extra precautions must be taken in using the land either for crops or for grazing. Overgrazing, for example, will strip off the natural vegetation which may be scant because of characteristic dry conditions. And since the rains that do fall in dry areas frequently are equally as intense as those that fall in more humid areas, susceptibility to exhausting erosion may be even greater than where there is more rainfall and accompanying denser cover of protective vegetation.

More details with respect to the distribution of land classes and their relative suitability for agriculture, grazing, and forestry are given under the rough classifications shown on the reconnaissance land map.

LAND USE IN THE MOUNTAINOUS COUNTRY OF NORTHERN VENEZUELA

In the greater part of the mountainous country of northern Venezuela, the better and more accessible lands have long been used for agricultural purposes at one time or another or are still in use. With the dense population occupying these highlands and the long period of agricultural use, it is in no way surprising that much land has been impaired in productivity and that many formerly cultivated areas have been essentially ruined by erosion and more or less continuous use for crops that have gradually sapped the fertility of the soil. The leisurely washing off of the capa vegetal, together with moderate to severe gullying, has finally impoverished the greater part of the more favorably situated uplands of some localities, even ruined some rather large areas permanently: washed the soil off, down to bedrock or made the land hopeless with yawning gullies.

A number of factors account for the frequent low yields and for the rapid failure of crops in dry weather, with consequent need for reclearing rastrojo and opening new fields in the too few remaining areas of virgin forest, now found principally at the higher altitudes on very steep slopes.

Prevailing declivity of the land, coupled with a dense population and limited opportunity for work off the farm, has induced or forced the cultivation of ever steeper and steeper slopes. Some of these areas -- many of them -- have slopes of 40, 50, 60, 70, and even in excess of 80 percent declivity, and some 100 percent, as determined by actual measurements in various localities throughout the mountainous farm country from Táchira and neighboring States eastward to Caracas and

beyond. Also, in some places livestock graze slopes up to 100 percent and occasionally even steeper than this. (Near Mérida we climbed such a slope that measured 102 percent: a fall of 102 feet in a horizontal distance of 100 feet.)

When the natural cover of vegetation is removed from such steep lands and the ground is broken or plowed for crops, or when the steep lands are too closely grazed or are too frequently bared of cover by fires, heavy rains tend to sweep the exposed, loosened soil down into the streams. This loss of the productive soil, the capa vegetal, often proceeds so slowly that farmers fail to recognize the process of wastage. But when his land becomes so impoverished that crops fail, or when the surface of the ground becomes so compact that most of the rainfall runs off the ground leaving little moisture in the soil for crops, the farmer quite naturally looks about for fresh land. If there is no suitable rastrojo to clear, he turns to the nearest available area of forest land and clears that. If there is no more forest land, he is forced to seek off-farm work, move to another locality, or ask for sustenance from relatives and friends or the community.

Another common practice that has contributed to declining yields -- in Venezuela and elsewhere is the planting of crops up and down the slope instead of across the slope, on the contour of the land. Such methods cause rainwater to run off the land so fast that it picks up and takes along the soil at a very destructive rate -- often all the soil, layer by layer, not just the plant nutrients.

It seems strange that many farmers throughout the world have somehow failed to work cooperatively with nature in such manner as to direct their plantings and furrows across the slope, along the contour, so as to intercept water flowing down through the fields and thus store more of it in the soil for crop use later on, and to check erosion. Failure to follow such practice has intensified soil wastage by erosion, across the ages, to such degree that people in many parts of the world have had to seek new lands or new occupations. Many large areas have been so disastrously affected by this wasteful process of erosion that whole civilizations have declined or even disappeared as the result. This has happened to once powerful nations in the old countries of the Near East and along the shores of the Mediterranean.2/

In some parts of the world, on the other hand, agricultural people have cultivated their land strictly on the contour and have even built walled terraces or benches along the slopes to hold the soil and to conserve rainwater by allowing it to sink into the ground for crop use in times of drought. Remarkable achievements along such lines of conservation of soil and water were carried out by the ancient people of Peru and even by the aborigines of the Philippines and New Guinea. In Peru, not only were the steep mountain slopes walled up for cultivation but water for irrigation was brought to them by splendidly engineered works.3/

Another cause contributing to diminished soil productivity and consequent occupation of more and more over-steep mountain land is the general failure to alternate crops in such a way that the land benefits from following those crops which tend to exhaust the soil of its plant nutrients with those crops that improve the soil by adding wholesome constituents -- nitrogen and organic matter. Such beneficial alternation or rotation of crops might, for example, be the growing of a legume, such as gallinazo or velvet bean, after or along with a crop of corn or yuca. The legumes add nitrogen to the soil and also much needed humus, especially if plowed under green. The corn, the yuca, the potato take nitrogen and other constituents out of the soil and return essentially nothing.

2/ Lowdermilk, W. C. Erosion-Control Lessons From Old-World Experience. Soil Conservation, Vol. V., Dec. 1939.

3/ Bennett, Hugh Hammond. Soil Conservation, McGraw Hill Book Co., New York, 1939. See pages 47-50.

Where grass is maintained on steep lands, soil erosion is greatly reduced or altogether prevented, especially if the pastures are not grazed by too many animals or are not grazed too much when the grass is too young or the ground is soft with rainfall. Often when pastures are grazed too closely, less palatable plants come in and crowd out the more palatable and nutritious plants.

Lands of still greater declivity than those than can be grazed safely can sometimes be more profitably utilized by planting to trees or by encouraging natural restoration of forests. The ordinary small farmer cannot do very much in the way of reforestation because he is forced to produce, on his limited acres, crops for food and for sale that can be harvested every year. But the people generally -- the States and Nation -- would be benefited by aiding in restoring forests to the high, steep lands. Where watersheds are completely stripped of their forests and where all the grassed lands are utilized for cultivation, too much of the rainfall flows off at once, as previously pointed out. This has led to the hazardous conditions of floods in the rainy season and to dry streams or streams that carry very little water during the dry season. As it has led to dry streams, dry wells, and dry springs, so it has led on to dry fields and human poverty and community decline. For example, in January, 1942, when the Mission was in Táchira, the water in the river at San Antonio was so low that, by arrangement, the farmers on the Colombia side were irrigating one week and those on the Venezuela side were using all the available water the next week. Other streams were seen that carried not a drop of water early in the dry season -- streams that were said to have formerly carried water well into the dry season or throughout the year.

As well as can be estimated with the information obtained in the Highlands of Venezuela, together with known results in other parts of the world, few farmers can make a satisfactory living on cultivated land steeper than about 25 to 30 percent declivity, except where the land is protected from erosion by an abundance of rocks naturally scattered over the surface. (The rocks protect the soil from erosion.) Even lands of much less declivity than 25 to 30 percent should be used according to wise conservation practices.

In the case of grazing, somewhat steeper slopes can be safely used when grazed with proper precautions -- even up to 60 or 70 percent declivity, under a sustained good cover of grass.

For forests almost any slope can be used except, of course, vertical and nearly vertical areas -- where there is little or no grazing and not many fires.

Need for additional information: Much additional information is needed on the technical aspects of agriculture as applying to different kinds of land found under conditions of great ranges in slope, altitude, and humidity. Procurement of such information can be speeded through careful experimentation, such as will supply comparative data with respect to the best methods and time of planting and cultivation; varieties; crop rotations; spraying where needed; efficient use of crop residues, livestock manures, and commercial fertilizers; and efficient use of both rainfall and irrigation water. Such experiments in order to be really useful should be carried out on the principal distinct types of land, at various altitudes; and the records should be carefully kept, year by year, until an adequate average of results is obtained to determine local needs. Interpretations of these records should be made for the practical use of practical farmers. Experimental and demonstrational work beyond the capacity of the farmer will not prove very helpful.

Need for demonstrations: It will not be sufficient merely to gather information on ways to prevent erosion, conserve soil and rainfall, increase yields, and otherwise improve agriculture. Such new information will be of no value unless it is carried out to the farms for practical use.

One way to do this is through ordinary methods of education: Talks to farmers, bulletins, newspaper articles and books describing the results of research. A still better way is to demonstrate the practices through actual work on the land -- on practical farms through cooperation with practical farmers.

Experience in the United States of North America has shown that the demonstration method of showing farmers how to use old practices, as well as new ones, has been highly effective in getting under way a national program of soil and water conservation.4/

Need for new lands: Where there is not sufficient land for all the people who want to live on the land, an alternative would be to help them find better farms in other localities. Such better lands occur in many localities. For example, the red hills and bench lands in the general vicinity of Colón and Estación Táchira, the unused alluvial lands at the southern end of Lake Maracaibo, the red Uribante soils and the brown Chururú soils found in places along the streams bearing these names and probably along other streams also, are of the type of better lands to which poor-land farmers might move, with adequate assistance. And such readjustments carried out in an economical way and with proper technical direction could easily benefit not only the farmer but many communities and the whole nation.

BROADLY GENERALIZED LAND TYPES OF THE HIGHLANDS

With the base maps available and the short time at the disposal of the Mission, it was impracticable to do any detailed mapping except on a number of farms where soil conservation work was carried out and on several proposed irrigation projects. The attempt was made nevertheless to record for all the country examined as many field observations and examinations as possible that pertained to the topography, climate, erosion, soil, vegetation, and agricultural conditions and possibilities. These have been recorded in a very generalized way on the best available map and noted in some detail in the descriptive section of the report. Some areas lying beyond the limits of actual observation have been included in the reconnaissance mapping with the observed types, on the basis of conditions indicated by the character of the surrounding country.

Much additional exploration will, of course, be necessary to refine the mapping, but it is felt that many of the more pertinent physical conditions are approximately represented in the descriptions that follow. These descriptions, while brief, are believed to be fairly representative of the dominant land and land-use characteristics. The boundaries shown on the map are only approximately correct. As a matter of fact, they generally have been projected mainly for the purpose of roughly locating some of the more predominant of the pertinent land conditions or groups of land conditions.

Severely Eroded Mountainous Country (humid climate)

The Severely Eroded Mountainous Country (humid climate) is a broadly defined type of land, generally unsuited to agriculture, that occurs in many parts of the humid sections of the Highlands of northern Venezuela. Several of the more extensive areas are shown on the accompanying land map.

The type is characterized by excessive erosion of both the sheet and gully type. All of the topsoil and most of the subsoil have been removed from large areas, and in many places there is active erosion in the softer parent materials. Many large gullies are becoming deeper and wider all the time. Not only do they destroy the land but they act as new channels that carry the water off the land, as flood flows, into the natural streams.

4/ Bennett, Hugh Hammond. Soil Conservation, McGraw Hill Book Co., New York, 1939.

Most of the slopes are steep -- above 25 percent. Some included areas, however, have slopes with gradients of 10 percent or less that are just as seriously eroded.

Virtually all of these lands have been cultivated at some time. Poor husbandry and the cultivation of steep slopes without any regard for the hazards of erosion or the use of conservation measures are responsible for present conditions. These excessively eroded areas are no longer fit for cultivation of any kind, nor can they be brought back into suitable condition for any agricultural use for generations to come, except to some possible extent for grazing through a process of exclusion of animals long enough for sufficient recovery of grass to permit controlled grazing.

Some of these almost completely denuded lands are now being used for grazing, but they furnish only scant forage. The animals -- mostly goats -- are able to obtain very little food, and yet, they promote erosion by loosening the soil and stripping the last vestiges of protective vegetation almost as soon as they sprout.

These severely eroded lands should be restored to some form of permanent vegetation, preferably forest. If grazing could be prohibited for several years most of the land would revegetate itself.

The soils occurring within these severely eroded areas consist chiefly of the Independencia, Lobatera, and Zumbador groups in the western highlands; and the Tovar, Guamita, and Guanta groups in the northern highlands.

Severely Eroded Mountainous Country (dry)

Figure 1. -- Severely eroded dry mountain country east of Lagunillas, Chama River Valley. Mérida.

This dry type of Severely Eroded Mountainous Country is mostly unsuited for farming. Overgrazing and the cutting of most of the limited number of trees in some of the drier mountain areas have produced conditions of erosion just as severe as those in the corresponding humid type of mountainous country. The problem of control or recovery is even more difficult because the low rainfall slows down the processes of revegetation (Figure 1).

The rainfall is too low generally to undertake any kind of reforestation. With complete exclusion of grazing for a few years and very rigid control thereafter, it is believed that nature itself would be able to repair much of the damage.

Much of the dry eroded lands would be of very little use except for limited grazing even if restored to the original condition. It is, however, very important that these lands be stabilized as nearly as may be practicable in order to protect the streams and lowlands from inpouring products of erosion (the debris of erosion).

Most of the slopes exceed 35 percent. There are a few included high terraces, along the streams, with relatively gentle slopes. These probably amount to less than 2 percent of the total area and in many places are just as severely eroded as the steep slopes.

The soils found on the included terraces are of the Barquisimeto and Motatán groups; on the steep slopes are the Barbacoas group and the dry-climate equivalent of the Zumbador soils, derived from red shales or sandstone.

No farming was seen except for a few patches on the terraces.

San Cristóbal Basin (humid)

The type of highlands country classified under the designation San Cristóbal Basin consists of relatively low bench lands, hills, and comparatively gentle slopes surrounded by mountainous lands that rise several thousand feet above the dominant level of the basin country. Actually, the country characterizing the type locality -- San Cristóbal, in the State of Táchira -- is a broad mountain basin of relatively smooth benches (including old alluvial terraces), isolated low hills, relatively smooth lower mountain slopes and steep higher mountain slopes, with interspersed strips of alluvial plains and low terraces such as those characterizing the lower valleys of the Torbes, Quinimari, and Carupo Rivers. Between the benches and the lower bottoms of the rivers the slopes are characteristically sharp, often of cliff-like character. Some of the higher hills and ridges have slopes that range up to declivities of around 50 percent or more. Also, a considerable part of the enclosing mountain slope land is decidedly steep locally, often 60 percent or steeper.

What is most important about these basin lands (and included broad valley areas) is that a fairly large proportion is much more favorable for cultivation (Figure 2). A rough estimate of the comparative availability for cultivation of basin floor land and surrounding mountainous country in the type locality of San Cristóbal would be about 65 to 75 percent of the former and 20 to 25 percent of the latter, or about 4 to 1 in favor of the basin floor type of country. Actually, a somewhat larger proportion of the mountain country is cultivated, at least in many localities (up to 50 percent or more in places). From the standpoint of slope suitability, it is estimated that from 50 to 60 percent of the land is cultivable (having a slope seldom more than 35 percent). Stoniness (steeper areas protected by covering of stones) brings the total of the cultivable land to about 65 to 75 percent of the whole basin country.

The elevation of the city of San Cristóbal, near the center of the type locality, and about representative of the smoother bench land portion of the area,

is 2,719 feet, but the range of elevation is about 1,586 feet in the lower part at Agua Dulce to 4,280 feet at Rio Chiquito. The crest of the mountains to the east of San Cristóbal rises to an elevation of 9,282 feet in Páramo La Ortuna, and to 6,724 feet in Alto de Teura.

The principal soils in the type locality of the San Cristóbal Basin Country are (not including the stream bottoms and low terraces) the Capácho, Torondoy, Lobatera, Independencia, Tabay, Zumbador, and Bramón groups. On the stream bottoms are found the Uribante, Estación and El Cobre soils. Texturally, the soils consist dominantly of heavy clay and clay, derived largely from shales (or slate), claystones, sandstones, and limestone.

These lands are extensively cultivated, the principal crops being corn, yuca, tobacco, sugar cane, gallinazo and pigeon peas, bananas, plantains, pineapples, a variety of vegetables, papaya, mango, citrus, and peanuts. Some livestock is raised and dairying is carried on by a good many operators near the larger towns. Some cheese is produced, especially in the cooler, high valleys.

In general erosion is only of moderate degree as compared with much of the mountain country used for similar agricultural operations. Details of erosion conditions are discussed under the description of the main soils presented below.

Figure 2. -- Favorable topography. San Christóbol Bosin near Palmira, Táchira. Yuca cultivoted up and down the slope.

The mean annual rainfall at San Cristóbal is 52 inches (10-year average). About 36 inches of this falls from May to October, inclusive. The mean annual

temperature at San Cristóbal is 75.6° F., the maximum is recorded as 88.5° F. and the minimum is 54.3° F.

The original forest of the type locality, now largely removed, consisted of that kind of mixed tropical forest which might be described as intermediate between rainforest and dry-forest. Among the important trees are cedro, majomo, anime, bucare, bálsamo, cedrillo, apamate rosado, and cascarilla.

Steep Mountain Land (humid)

The Steep Mountain Land type is the most extensive of the mountain types. It is predominantly steep -- over 35 percent, with a considerable part running over 60 percent. As contrasted with the Very Steep Mountain Land, however, there are few or no cliffs and very little rough stony land. As a type, the chief distinguishing characteristic is its steepness.

Included with the Steep Mountain Land are small areas on shelf-like or bench positions having gentler average slopes that make them suitable for cultivation. These benches comprise a very small part of the total area -- not more than 7 or 8 percent. Another 8 to 10 percent of gentler sloping land -- of less than 25 percent declivity -- not occurring on benches is suitable for cultivation where good soil management is practiced. Thus the type includes an estimated area of cultivable land amounting to 16 to 18 percent of the total, that is, as considered from the standpoint of slope. Erosion conditions and susceptibility will reduce this amount to probably not more than 10 or 15 percent of the total.

Much of this exceedingly steep land, however, has been or is being cultivated. A large proportion of the cultivated mountain lands falls within this type. The greater part has suffered disastrously from the ravages of erosion, much of it as seriously as that described under the severely eroded mountain type. But the individual areas are generally not large enough to delineate on a map of the scale employed.

It is estimated that 70 to 80 percent of the type should be reforested, either artificially or naturally. Other areas should be retired to grass.

In the Western Highlands the principal soils are the Tabay, Lobatera, Zumbador, Mucuchies, Altamira, Bramón, and Capacho. In the Northern Highlands they are chiefly of the Tovar and Guamita groups. On the alluvial terraces and stream bottoms the Valencia, Maracay, Vega Baja, Taborda, Alpargatón, San Felipe, Tarbera, Gucara, Ocumare, Camoruco, and Marquez are the principal groups. Soils which are more typically and extensively developed in the Llanos are also found in the savanna areas of the Highlands. The Guataparo and Tamanaco groups are the most commonly found.

Steep Mountain Land (humid: mainly forested)

The forested type of Steep Mountain Land is largely covered with heavy forest of the type that has never been cleared. As indicated on the reconnaissance land map, the type consists mostly of rough mountain country largely above 6,500 feet elevation and having a high rainfall. The greater part of the type is too steep or rough for other economic use than forestry. A typical representation of this class of land can be seen along the new mountain road from Bramón to Las Delicias. The elevations of the dominating peaks of this heavily forested area are 6,052 feet on Bajal and 9,337 feet at the summit of Tabor. In the large area bordering the San Cristóbal Basin on the South and East, elevations range up to around 9,000 feet.

Although the slopes are predominantly very steep, sometimes in excess of 100 percent, with some cliffs and near-cliffs, an occasional farmer has cleared off the forest and planted yuca, corn and peas. Every effort should be made to

preserve these splendid forests, representing some of the more important of the remaining areas of Venezuela's good mountain forest. They not only contain many valuable trees that could be taken out under good forest practice but they serve to keep alive highly important mountain streams, the waters of which are needed by the farmers and towns of the lower country. Moreover, the clearing of these steep lands is sure to be followed by destructive erosion.

Among the important trees found in this type of forest, as seen near Las Delicias and to the north of Colón in the State of Táchira, are camaney, hatate, caleo de hacha, conalito, carne asada, jobo, apomato blanco, and palo sano.

Other important areas of virgin forest of this general land type are to be seen in the national forest in the mountains to the north of Lake Valencia, on the mountain slopes bordering the Tocuyo River, and in the mountains to the south of Caucagua.

Very Steep Mountain Land (humid)

Very Steep Mountain Land is largely non-arable or inaccessible. A typical area is that lying to the west of a line from the vicinity of Rubio to Lobatera and extending to the vicinity of El Corozo in the State of Táchira. Other smaller areas occur in the State of Miranda, Monagas, and Sucre.

Much of the land consists of cliffs and near-cliffs, probably 30 to 50 percent. About 40 to 50 percent has a gradient of 90 percent or more, as well as could be estimated. Streams running from the main area through adjoining drier country on the west are nearly all of intermittent flow. Excessive runoff has caused extensive gullying, even of some of the gentler sloping land, such as that along the Táchira River and the road from San Antonio to Urena. Erosion conditions in cultivated and previously cultivated areas and on overgrazed lands range from moderate to excessively severe. Deforestation, clean tillage, and overgrazing have reduced the cover of vegetation to such poor state that erosion conditions are becoming steadily worse.

The greater part of this type is definitely non-agricultural. Not more than about 2 percent is in cultivation at present. It should be used for forest and limited grazing. Timber and firewood cutting should be rigidly controlled, since the land is highly erodible. A good cover of forest would provide considerable watershed protection. The principal soils belong to the Lobatera, Bramón, Tabay, Independencia, and Capacho groups.

Moderately Steep Mountain Land (subhumid)

This moderately steep type of mountain land is topographically similar to Steep Mountain Land, although in general the slopes are somewhat gentler and less rugged.

The type is largely devoted to grazing, along with some farming. The vegetation consists chiefly of grass and rastrojo or scrub forest. There are no stands of heavy forest like those on the forested phase of Steep Mountain Land.

Much of this land was cultivated at one time or another, but is now abandoned to rastrojo or grass.

Although about 70 or 75 percent of the type, as estimated, is too steep for cultivation, the slopes in general, however, average not so steep as those of Steep Mountain Land. But there is no great difference; the latter includes some 5 to 10 percent more land that is too steep for cultivation than the former. In the Moderately Steep type slopes fall dominantly within a range of from 25 to 50 percent gradient. Not much of the land exceeds a declivity of 60 percent. In case of the Steep type, however, most of the slopes range from 35 to 60 percent gradient, with a considerable part exceeding 60 percent.

This predominantly milder declivity accounts for the generally less severe erosion conditions characterizing the type. It is estimated that approximately 70 percent of the total area of the type should either be reforested or kept in grass for use under conditions of controlled grazing. The gentler slopes are more accessible and more favorable for grazing than the steeper mountain land.

The other 25 to 30 percent is rated as being mostly suitable for cultivation, that is, where good soil management is practiced, including the use of effective soil and water conservation measures. Only a small part is adapted to clean tilled crops without the use of protective measures against erosion. Much of the arable area is not suitable for continuous cultivation and should be used for that purpose only about one year out of three to five or six years. Grass and other cover crops should be grown during off-cultivation years.

Among the soil series found within the limits of this type are the Capacho, Tabay, Independencia, and Lobatera, in the Western Highlands Sector, and the Tovar, Guamita, Bramón, and Capacho in the Northern Highlands.

Páramo (humid)

The Páramos, as roughly classed for the purposes of this investigation, comprise all lands lying above timber line -- that is, above an approximate elevation of 11,000 feet. Included with the type are some small areas of relatively gently sloping, plateau-like land, some steep mountain slopes, bare rock, and craggy peaks partly covered with snow and small glaciers.

The vegetation is of the alpine type: grasses, weeds, and heather-like plants, for the most part. A few scrubby trees are found in places near the lower limits. Many of the high peaks are completely bare of plant life except for lichens and mosses.

None of the land is farmed. It is used only for limited grazing of cows, horses, and sheep. Because of cool climate and shallow soils, the land has no promise for any kind of cultivation.

Erosion on the high peaks and steeper slopes is of the geological order. Some of the smoother land used for grazing has suffered from overgrazing and resultant erosion. The soil is characteristically shallow, loose, and highly erodible. Erosion not only damages the land locally but is the source of difficulties for the agricultural lands below.

Only one soil group was seen: the Páramo.

Caucagua Hills (humid)

The type of land called Caucagua Hills consists predominantly of foothills and lower mountain slopes. In general the slopes are not so steep as in the associated mountainous country. Predominantly the declivity is somewhat under 35 percent, only a small part has gradients of more than 50 percent.

The type has the advantage of a rather regularly distributed rainfall. At the time of the Mission's visit to Caucagua, in late January 1942 (that is, well into the dry season for most of the country), the Caucagua Hills were very green and no crops or plants were suffering for want of water.

These lands originally were rather heavily forested, but only small scattered areas of the original type of growth remains. Uncultivated areas -- former fields and pastures -- are now mostly covered with rastrojo.

Most of the land has been cultivated at one time or another. Inefficient tillage and lack of soil conservation have had serious consequences. Erosion on

cultivated and formerly cultivated lands generally ranges from moderate to serious, although conditions in general are better than on the lands of the other steeper mountain types.

With good conservation practices, it is estimated that about 25 percent of the area could be cultivated safely. The remainder should be turned to forest or grass, preferably the former.

The Caucagua Hills type locality lies to the north of Caucagua, in the State of Miranda. Another similar and larger area is that in the State of Monagas, near San Antonio de Maturín and Caripe.

In the vicinity of Caucagua the predominant soils of the uplands are the Tovar and Guamita. In Monagas the Capacho, Bramón, and Lobatera seem to be the principal groups. On terraces and stream bottoms the Valencia and Maracay groups dominate.

High Mountain Valleys and Adjacent Lower Slopes (humid)

Figure 3. -- Characteristic topography of High Mountain Valley and Lower Slope land type, near Bailadores, State of Mérida.

These high mountain valleys and slopes are typically developed in the vicinity of La Grita, in the State of Táchira.

The valley areas consist of alluvial first bottoms and associated terraces; the mountain areas are represented by lower slopes bordering the alluvial lands (Figure 3). Most of the latter portion of the type is of milder gradient than that prevailing in the Western Highlands. At the same time, however, a large proportion of these slopes is too steep for continuous clean cultivation, in fact, much of the land should be retired to grass or forest.

Erosion conditions in general are of slight importance on the first bottoms, moderate on the terraces, and serious to very severe on the adjacent mountain slopes. Much of the erosion on the terraces is the result of excessive runoff and erosion from neighboring cultivated mountain slopes.

These mountain valleys and enclosing slopes include a large proportion of the better farming lands of the local highlands. Virtually all of the bottoms and terraces are well suited to general agriculture, with very little hazard of erosion apart from that caused by runoff from the enclosing slopes. Erosion is becoming progressively more damaging on the slopes. Many areas already have been ruined for any further cultivation, and still others have been so impaired by sheet washing that the yields of corn have dropped in some fields to the pitiful amount of from around 3 to 5 bushels an acre.

The smooth valley lands, however, are admirably suited to general farming. Row crops, such as corn, potatoes, beans, and a variety of vegetables, are grown on both the terraces and first bottoms, along with some grass, for stock feed, and fruits grown on the adjacent gentler slopes. The steeper, more eroded slopes should be reforested.

The principal soils seen are those of the Bailadores, Mucuchies, and Zumbador groups.

Rough Stony Low Mountain Land (humid)

These rough stony lands are found in typical development around Cuicas and near Carache and to the east in the State of Trujillo.

The type is characterized by numerous low cliffs and steep slopes, with an abundance of large boulders (up to 20 feet or more in diameter) scattered over the surface. Considerable cultivation is carried on among the rocks, which serve to prevent or minimize the effects of erosion, even on slopes of 30 percent or more. In several localities corn fields were seen where the estimated yield ranges from 15 to 30 bushels an acre.

The boulders consist mostly of sandstone, but some limestone occurs in places. The soils are of the Bramón and Capacho groups.

These lands can be cultivated without very serious hazard of erosion because of the protection afforded by the highly absorptive character and rough surface of the stony land. Nevertheless, contour cultivation undoubtedly would prove beneficial. Much of the type, however, 60 percent or more, is too steep for cultivation and should be used for forest or grass, preferably the former.

Low Mountains (subhumid)

This Low Mountains land type includes the low, rounded mountains extending along the coast from near Boca de Uchire eastward to a point just west of Cumaná. South of Barcelona the area broadens out and extends eastward to Mundo Nuevo, thence northward to Cumaná.

Topographically, these mountain lands are low and rounded. Between Boca de Uchire and Barcelona the elevation is generally less than 1,000 feet; eastward from Barcelona they rise gradually to heights of as much as 3,000 feet above sea level.

The vegetation consists of a rather dense stand of dry forest. The trees that were identified are indio desnudo, olivo, cautaro, barablanca, black cují, maya, a plant closely resembling sisal, and an occasional cardón cactus.

Erosion conditions range from moderate to severe, caused largely by over-

grazing by goats. Large areas occupied by the Guanta soils have suffered very severely from erosion, even where covered by a good stand of small trees and brush.

The rainfall is generally low. The 20-year averages of Cumaná and Barcelona are 15 and 25 inches, respectively. Most of this falls during the 6-months period of June to November, inclusive.

No cultivation was seen, the main agricultural pursuit being grazing. Most of the animals raised are goats.

The obvious principal value of the type is for grazing and the production of wood for fuel. Only the most rigorous employment of grazing control measures will serve to control or even impede in any important degree the rapid erosion going on over these lands.

The principal soil groups are the Guanta, La Cruz, Barbacoas, and Motatan. In addition, the Cumaná, Barcelona, and Valencia groups are encountered along the ocean front and on low river terraces.

Rolling Benchlands and Lower Slopes of Adjacent Mountains Largely Covered with Rainforest (very humid)

The type locality of these bench lands and associated lower slopes extends northward from Maturín in the State of Monagas to El Pilar in the State of Sucre. The classification includes rolling terraces and relatively smooth lower slopes of the adjacent mountains.

Except for a few small plantings of bananas, yuca, and beans, the entire type is in forest -- mostly rainforest. Because of this well vegetated condition erosion is not a problem. If any of it should be cultivated, however, effective erosion-control practices should be used to prevent disastrous consequences from erosion -- due to the generally steep slopes and high rainfall.

Seedling Hevea rubber trees at the nursery of the Standard Oil Company, near Caripito, were growing splendidly. It is believed that here is one of the best parts of Venezuela, north of the Orinoco, for rubber production. The rolling terrace lands seem to be especially adapted to the crop. It is imperative, however, that any plantings of rubber trees, or any other cultivated crop, should be made on the contour.

Other areas of the type occur along the Yaracuy River and its tributaries in the States of Carabobo and Yaracuy. These, too, as well as portions of the associated bottomlands, are probably suitable for rubber. Another small area lies just east of Mene Grande, in the State of Zulia.

The principal soil groups are the Quiriquire and Pampanito on the terraces, Capacho and Bramón on the mountains slopes, and Guanoco, Caripito, and Toa on the first bottoms.

Savanna Hills (subhumid to humid)

The Savanna Hills type of land typically consists of low, rounded hills lying along the border between the Llanos and the Highlands. They are in reality a part of the mountain belt but have been separated on the bases of soils, vegetation, and generally lower altitude.

These lands are used only for grazing. They are burned over annually, almost in their entirety. This may have some effect in reducing the relative abundance of the more palatable grasses, but no outstanding evidence of any particular effect on the soil could be observed.

The rainfall ranges from subhumid to humid, according to elevation and locality.

The principal soils are those of the shallow, droughty Sarare group and the Motatán group. The typical vegetation is composed of savanna grasses, with scattered chaparro trees. The grass cover generally is heavy, even where bedrock is exposed. Apparently, there has never been a deep soil mantle on these hills. The large exposures of bedrock are due to natural geologic erosion. The grasses are rather coarse for the most part. Improvement for grazing possibly could be made in some places by seedling molasses grass.

Savanna Mountains (subhumid to humid)

The Savanna Mountains classification was established almost entirely on the basis of its vegetative characteristics: an almost unbroken cover of Savanna grasses, along with scattered trees -- principally chaparro. This type of land is confined largely to the southerly range of the Northern Highlands. It occurs also to the north of Lake Valencia on the south-facing slope of the coastal range of the Northern Highlands. They are more or less rounded, with comparatively little excessively steep land.

Less erosion is seen on the Savanna Mountains type of land than on any other of the mountainous types, except those covered with virgin forest. This generally slight degree of erosion is due to the fact that very little of the land is cultivated. What little is cultivated is confined largely to the occasional narrow stream bottoms. There are some eroded areas, however, which have resulted from a combination of overgrazing and annual burning.

The soil generally is very shallow. Rock exposures are not uncommon. This for the most part is a natural condition.

The Savanna Mountains type is suitable only for grazing. It is not naturally high quality land and much of the grass becomes tough at an early stage. Seedings of the highly drought-resistant grass known as Molasses Grass possibly would improve the grazing.

The principal upland soils belong to the Sarare, Morros, Guamita, and La Cruz groups. On the terraces the La Puerta and Maracay are predominant.

Old Eroded Terraces (subhumid)

These old eroded terrace lands consist of roughly dissected high terraces, with relatively small mesa-like remnants. In places along streams and surrounding some of the mesas, escarpments of mixed gravel, sand, cobbles, boulders, and fine material rise very steeply or vertically to heights of 100 feet or more. Except on the nearly flat mesas, the soils are very gravelly and droughty.

Cultivable land is confined almost entirely to the mesa positions. Some of the very steep slopes are cultivated, but with poor success. On the flat positions the crops seen in both irrigated and non-irrigated fields generally were good.

Vegetation for the most part consists of a rather scrubby type of dry-forest. Chaparro, marfil, cují, and cactus are commonly present.

Most of the land is heavily overgrazed. Considerable severe erosion has resulted from such abuse. Controlled grazing would improve the situation in time. Probably the best use, however, would be maintenance in forest for the production of fuel and for watershed protection.

The principal soils are of the Motatán (on the slopes), and the Pampanito groups and Tamanaco (on the flat mesas).

Rolling Alluvial Terraces (subhumid to humid)

A moderately extensive area of rolling to steeply rolling terrace land found along Tuy River has been classed as Rolling Alluvial Terraces. Beginning in the vicinity of Tacata, the area extends eastward on both sides of the Tuy to beyond Panaquire.

The land is predominantly rolling, but just above the first bottoms or low terraces occurs some narrow strips of nearly level areas of high terrace land. The topography in general resembles that of the rolling Llanos of the Unare River Basin.5/

The dominant original vegetation was forest of moderate density. Much of the land has been farmed at one time or another, but apparently none of it has been cultivated continuously for any great length of time. At present about 10 percent is in cultivation or used for grass, chiefly gamelote. The principal crops are corn, beans, and peanuts. At the time of the visit by the Soil Conservation Mission in January 1942 -- well into the dry season -- these crops were only fair. Yields of 1,200 kilos per hectare of peanuts were reported for seasons of good rains. Gamelote grass was very good.

The chief soils of the locality are the Charallave, Pampanito, Loma, and Palacio. They are among the good soils of the country. In addition the Ocumare, Valencia, and Maracay soils occur on the first bottoms and on the low terraces immediately along the river.

There is good reason to consider this as a region capable of extensive agricultural development for general farming and dairying.

Erosion conditions range from slight to moderate, with very little land seriously affected. This is attributed to low erodibility of the soil. It does not follow, however, that erosion-control measures are not needed. Contour stripping, terracing, and contour cultivation would serve admirably for the control of erosion and conservation of rainfall.

The Mendoza Colony is located partly on this kind of land. Here is an excellent opportunity, it seems, for the establishment of conservation practices on a rather large area of land, on a cooperative or group basis. The administrative machinery is already established, and with technical assistance it should be a relatively simple matter to get a good program moving.

High Mountain Slopes and Valleys (humid -- wheat belt)

High Mountain Slopes and Valleys is a rough classification designed to cover steep mountain slopes and associated flat lands of the valley floors. The type locality is near Mucuchies in the State of Mérida. Here is the principal wheat-producing area of the country.

The rainfall is high -- 70 inches or more. It is quite well distributed throughout the year. There is no very pronounced dry season and the true situation with respect to precipitation may be described as alternating seasons of high and low rainfall.

Most of the area originally was forested. This was heavy timber at the lower altitudes (around 5,000 feet), but it gradually thinned with increasing altitude, giving way finally to the alpine vegetation in the Páramos.

The greater part of the area occupies slopes in excess of 25 percent. At

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5/ According to the Mapa Geológico de Venezuela, prepared by A. Jahn, the shale and limestone beds occurring in the two places are of the same geologic age.

least 70 percent of the area is too steep for safe cultivation and probably should be retired to some form of permanent vegetation, either forest or grass.

Figure 4. -- Destructive erosion ot High Mountain Slopes type ot Son Rofoel, Stote of Mérido. Light colored oreos between gullies used for wheot in 1942. This slope meosured 46 per cent.

Most of the land has suffered severely from the effects of erosion; some of it has been completely ruined for cultivation and abandoned (Figure 4). On the more stony areas erosion has not caused so much damage. The rocks have served to retard the process.

Figure 5. -- Poor yield of wheat (about 2 or 3 bushels per acre) on sheet eroded steep wheat land, near Apartaderos, State of Mérida.

Figure 5a. -- Wheat yields on soil retained behind stone walls sometimes goes up to about 20 bushels an acre in the vicinity of Mucuchies.

Most of the wheat produced in Venezuela is grown in the State of Mérida, on these steep mountain slopes and the associated smoother valley lands. Estimated yields range from around 2 or 3 bushels an acre in the older fields (Figure 5) and on the more eroded slopes to about 16 bushels or a little more an acre on the better of the smoother valley lands. Other crops are barley and oats (in small amounts), corn, a variety of vegetables, and potatoes of excellent quality.(Figure 5A)

Figure 6. -- Steep land of the Andean wheat belt near Timotes, State of Mérida, that should be retired to trees. Rill erosion produced by a rain of previous day.

Control of erosion in the wheat belt will involve very marked changes in farming practices. About 65 to 75 percent of the land should be retired to grass or trees (Figure 6). A change to a more diversified type of agriculture, such as fruit growing and dairy farming, with small grain and row crops on the gentler slopes, would aid greatly. Fruit trees planted on the contour with grass strips in between would be very effective on many of the steep slopes. Crop rotations, including the legumes (as perhaps some of the lupines, clovers, and high-altitude peas) would help increase yields.

Potatoes of excellent quality and size are now being grown in this high mountain area. These might be tried at lower altitudes for seed. The climate and rainfall are such as to favor the growing of a much wider variety of vegetables than is now produced.

Increased crop diversification would serve the three-fold purpose of reducing the devastating effects of erosion, increasing farm income, and bettering the general health.

The principal soils seen on the mountain slopes are Mucuchies, Tabay and Zumbador groups. The Mérida, Bailadores, and El Cobre are found on the terraces and stream bottoms.

HILLS AND BASINS OF LARA

The area designated as the Hills and Basins of Lara is, as the name implies, situated chiefly in the State of Lara. It is roughly enclosed within a line extending from the vicinity of Barquisimeto southwesterly to Guárico, thence to the lowlands of the Maracaibo Basin on the west, thence northeasterly to the vicinity of Siquisiqui, and finally back to the starting point.

Topography: Physiographically the Hills and Basins of Lara are a part of the Highlands of Venezuela -- a relatively low area amounting to what is generally considered a break in the range. The area lies between a somewhat higher belt of hills or low mountains on the south and the Segovia Highlands on the north. The altitude is generally lower than that of these enclosing regions. The cities of Barquisimeto and Carora are situated on representative basin areas at elevations of 1,857 and 1,345 feet, respectively. The associated hills range in elevation from about 1,500 to around 3,000 feet or a little more.

Topographically this Hills and Basins country is characterized by low, rounded hills usually occurring in clusters, with intervening or interspersed low flats or basins. Formerly, shallow lakes occurred in some of these depression areas, as in the vicinity of Los Arangues, where a typical lake is said to have dried up within historical time.

Most of the hills have been severely eroded, chiefly because of overgrazing by goats. Over extensive areas not a vestige of the former soil mantle remains. In many places both soil and subsoil have been swept away bodily, exposing the parent rocks: mainly phyllite and limestone. In some localities it is possible to travel miles in any direction without finding either soil or subsoil except for occasional inconsequential patches or pockets that have been left through some such protective accident as a flat or shoulder configuration of the surface or a crack in the exposed bedrock. A sparse growth of scrub cují and cactus makes it possible for a large number of foot-loose goats to eke out a precarious existence. These plants find something of a footing in the pockets of soil material left here and there, as in cracks or fissures in rocks and in protective flats and depressions of diminutive size.

The basins are occupied by water transported materials derived from the eroding hills. These water-lain materials exhibit all stages of soil-profile development. During the rainy season the basins are so flooded at times that serious damage to highways and trails results. Severe erosion takes place even on land having gradients of less than one percent. Often traffic is held up for several days because of damage by floodwaters.

Vegetation and erosion: The vegetation in the basins is quite similar to that on the surrounding hills but generally the cover is heavier. Some places are covered by almost impenetrable thickets of cactus (cardón). Here, as in the hills, very little forage is left, either of grass, weeds, or shrubs. And even the leaves of the remaining cují trees have been eaten off to the full height of a hungry goat's reach.

In general the vegetation throughout the region is the same -- largely cují, yabo, and several kinds of cacti. Variations in relative thickness of stand from place to place are chiefly the result of degree of erosion, elevation, soil, and diversity of rainfall.

The climate is semi-arid. The average precipitation at Barquisimeto (19 years of record) is 19 inches and at Carora (20 years of record) it is 25 inches. Approximately 80 percent of the rain falls in a six-month period. The mean annual temperature is high.

Farming is confined principally to irrigated river bottoms and to small acreages of sisal grown on the inter-hill flats. The main source of livelihood for most of the rural people is derived from goats. Large numbers of these animals are raised for meat and for the production of cheese. The goats are responsible for most of the deplorable land conditions existing over many thousands of acres. By eating every sprig of vegetation from every square inch of ground accessible to their teeth, nature's protective cover of plants has been stripped from the land and the land thus laid bare to the terrific impact of rains. Along with the vegetation is gone also the productive soil -- the principal capital of the people who live on the land or indirectly by trade or other activity based on products of the land.

In a number of places we counted the living plants on measured areas fairly representative of the severe erosion conditions that have affected several hundred thousand acres of land in the Hills and Basins of Lara. In one place of 500 square feet, we found, in December, 4 sprigs of grass (not over 2 inches high), 3 small weeds, 4 cují sprouts (seeds sprouted since the close of the rainy season a few weeks earlier), and 2 living cují trees. Remnants of dead cují trees were strewn about the surface of the ground rather thickly, showing that previously many areas now in a skeletonized condition with respect to soil supported comparatively dense stands of cují forests. Undoubtedly many more goats were supported then than now, and it is likely the animals were in better condition than the quite thin ones you never get beyond sight of in this country.

The sprigs of grass that we counted in the measured plot referred to, and saw in other places, were there because they grew between rocks or in fissures in exposed bedrock in such a way that the animals could only chew off the tops. About the same was true of the several slender weeds we were able to locate. The cují sprouts were those that at the time had escaped the notice of the animals. No doubt they subsequently were hunted down, one by one, and devoured. Nowhere is the vegetation making progress. On the contrary, it is practically everywhere in state of retrogression except in those places where it already has been eliminated.

The degree of erosion has not stopped everywhere with removal of the capa vegetal and then the subsoil. In many places trampling by goats has ground up some of the soft phyllite rock, and part of this, too, has been washed downslope or into the streams. Even the topography of numerous tracts of land has been altered in detail. Goats traveling across the slopes and more or less obliquely upslope and downslope have developed small trails that have some resemblance to diminutive terraces. The oblique grazing trails join those that cross the slope along lines that approach the contour to form a rough network of diamond-shaped earth scars; grazing patterns of the goat.

From the top of a neighboring hill, it was estimated, on the basis of reconnaissance observations in the locality, that the view embraced an area of approximately 190,000 acres, all of which had lost all of the topsoil and most of it all of the subsoil down to bedrock. This view included some of the very hilly country along both sides of the quebrada whose bottom constitutes the road for several kilometers from above Los Yabos in the direction of Carora (a new road was being built around this section).

Land use: The presence of an occasional remnant of grass and weed and a few sprouting cují seeds is referred to because of the probable highly important significance of these plant remnants. Their very existence under the unfavorable land conditions -- such as absence of any real soil or extreme scarcity of soil and intensified conditions of desiccation caused by erosion -- is strong evidence that with an adequate period of rest from grazing a very considerable recovery of vegetation -- vegetation relished by goats and other animals -- would come about. It is believed that exclusion of all grazing animals by some type of effective fencing would within the course of possibly 3 to 5 or 6 years allow sufficient

re-establishment of vegetation in some places to resume grazing under controlled conditions. So long as the vegetation continues to show a condition of improvement more animals could be grazed on the range.

It is further believed that within periods of 10 years or less these desert-like lands could be made to support more goats than at present, and they would be better goats, with more meat, more milk, and better hides. There is no doubt but that this section is adapted to a goat economy, but no country is adapted to any type of land use that undermines the economic base of agriculture -- that is, the productive soil and the plant life.

BROADLY GENERALIZED LAND TYPES OF THE HILLS AND BASINS OF LARA

Rough Hill Country

The area designated as Rough Hill Country, lies to the east of Mene Grande. It is typically developed along the boundary between Lara and Zulia. It more or less parallels the eastern shore of Lake Maracaibo at distances of from 10 to 30 kilometers back from the shore line, and forms part of the boundary enclosing the Maracaibo Basin.

These hills range up to the proportions of mountains, but the altitude is generally less than 2,500 feet. They are rugged, lacking the rounded appearance characteristic of most of the low mountains of the country. The vegetation seems to be predominantly dry-forest, of varying degree of density. Locally, however, portions of the forest occupying the west-facing slopes approach the character and density of rainforest.

Because of their roughness and relative inaccessibility, together with their apparent low value for cultivation, detailed examinations were not made.

As well as could be ascertained very few people live in the area. It is believed that most of this kind of land can best be used for trees and as a watershed-protection area. The major portion of the land is covered with forest. This is probably the best use for it. Operating on a sustained-production basis and making use of sound forestry practice, these hills have the appearance of some promise for profitable forestry use. Their position with respect to adjacent lowlands is such that very great care should be taken to prevent any such abusive land use as steep-slope farming, overgrazing, and excessive cutting or burning, since such mistreatment of the land would very likely develop an erosion problem that would constitute a distinct hazard to the lands between the hills and Lake Maracaibo.

Rounded Hills and Low Mountains (dry to subhumid)

These rounded hills and low mountains are abundantly covered in many places with boulders (mostly yellowish sandstone, according to a few observations) ranging up to 10 feet in diameter. The vegetation is intermediate in character between the dry-forest type and that common to the low humid mountainous country. These lands are found principally in the southwestern part of the State of Lara, in the vicinity of Los Arangues.

Though heavily overgrazed much of the land has still not suffered greatly from erosion. This is due to the protection afforded by the surface covering of stones. Other areas included with the type are underlain by shale or phyllite. These have suffered considerably from erosion, in many places severely.

The vegetation consists of cují and a few other small trees, with an occasional cardón cactus. Only a small part of the type is suitable for cultivation. Its best use is for the production of fuel wood, grazing, and watershed protection. If good conservation practices should be used on this land, it is very probable

that the water supply would be restored to a point where the basin country around Los Arangues could again be irrigated.

The only soil found is the Barbacoas.

Old Terrace Lands and Filled-in Basins (dry -- Barquisimeto Type)

The Barquisimeto Type of old terraces and filled-in basins is indicated on the land type map only in the larger areas -- chiefly in the State of Lara.

The basins included under this designation are not completely enclosed and all or most of them have drainage outlets. They are level to undulating, with very few slopes exceeding a gradient of 5 percent. Most of the steeper slopes occur along the base of the adjacent hills.

Figure 7. -- Severe erosion on nearly level basin land of the Barquisimeto type, near Quibor, State of Lara. Overgrazing by goats caused the downfall of this

Erosion in general is severe and of varied types (Figure 7). Some of the basins have suffered critically from sheet erosion; others are badly gullied and a few have been affected by deposition of erosion debris from neighboring hills. Excessive runoff from the denuded hills, together with overgrazed conditions in the basins, has been the principal cause of the severe washing of the basin lands.

The vegetation is of the semi-desert cují-cactus type, sparse for the most part, due probably, to a considerable degree, to overgrazing by goats. In some places, as along the main trans-Andean highway west of Barquisimeto, occur almost impenetrable stands of cardón cactus.

The basin area near Los Arangues supports a different type of vegetation at least to the extent of being of heavier growth, mainly because of the higher rainfall.

About twenty-five years ago, according to Señor Montes de Oca, Jefe Civil of Carora, there was a shallow lake in this locality and the surrounding basin lands were irrigated and planted to sugar cane. Because of the constantly diminishing water supply, however, the owners finally were forced to give up their irrigation farming activities. A former sugar cane plantation has reverted to rastrojo and is being used for grazing.

The only farming observed on the type was the growing of sisal. The results with this crop seemed promising. There is still a fairly large unused acreage of land suitable for the growing of this valuable crop. Good range management practices, such as contour furrowing and water spreading in conjunction with adequately controlled grazing, would improve the range and better the livestock situation.

The principal soils are those of the El Tocuyo, Quiber, Carora, Los Arangues, and Barquisimeto groups.

Severely Eroded Low Hills (dry)

The land type Severely Eroded Low Hills consists, as the name implies, of severely eroded hill country, associated with the Barquisimeto type of basin country. It is found chiefly in the State of Lara. Other similar areas occur along the coast in the States of Falcón and Sucre and are described under the Coastal Region of Falcón. As broadly delineated on the map, the type includes many unmapped small basins, narrow stream bottoms, and areas of less severely eroded hill lands.

It is estimated that from 75 to 90 percent of the land classified under this designation has been severely affected by erosion. The degree of damage ranges from a condition of deep gullying to a condition where all the soil has been removed to bedrock. In places even the bedrock -- the softer weathered rock -- has been cut into. A large proportion of the hills north and west of Barquisimeto is made up of low rounded hills from which both topsoil and subsoil have been removed, leaving behind exposed rock or only pocket accumulations of a mixture of phyllite (a highly fissile micaceous schist) fragments, caliche, and soil material. The present vegetation is exceedingly sparse. With respect to plant numbers, it may represent now no more than about 1 or 2 percent of what it was under virgin conditions.

Other large areas just as severely eroded, considering the amount of material removed, are of a more favorable nature with respect to plant growth. Even though all the soil has been removed, the softer exposed parent rock material represents a somewhat better footing for plants. This included type is of reddish color as contrasted with the characteristic gray color of the phyllite hills. The parent rock of this reddish soil, as seen in the vicinity of Bobare and in various places in Falcón and Sucre, consists of a soft shale-like rock.

Much of the type has been damaged beyond the possibility of anything approaching complete repair for generations to come. The land can be improved in some measure for plant growth, however, by controlled grazing. Construction of diversion ditches for flooding many of the small included basins and stream bottoms, as seen along the road to Bobare, will make it possible to supplement the impoverished forage supply of the range by growing grass and sorghums. As pointed out above, it would be advisable, probably everywhere, to improve range conditions by adjusting animal numbers and grazing practices to the capacity of the range to support the animals without vegetative retrogression.

The vegetation, as already pointed out, consists chiefly of a semi-desert or dry-forest type, that is cují, cardón cactus, the pitahaya, tuna (prickly pear), and a species of barrel cactus. Along small intermittent drainages and in deeply incised draws where the watertable is nearer the surface the vegetation is more varied and plentiful. Here are found such trees and shrubs as yabo (a green bark

tree, with waxy coating), amarilla, suspire, and flor amarilla (one of the many trees of Venezuela known under this name).

No definite soils groups can be described for the simple reason that none exist. The small scattered areas of soil occurring in the included basins belong for the most part to the Barquisimeto group.

THE COASTAL REGION OF FALCÓN

The Coastal Region of Falcón parallels the coastline in a strip averaging about 30 kilometers in width (not including the Península de Paraguaná).

Topography: One part of the area begins at the boundary line between the States of Zulia and Falcón and continues eastward a little beyond the city of Coro. Physiographically the area constitutes a continuation of the flat terraces bordering Lake Maracaibo. The area is composed of several land types that owe their distinguishing characteristics to some one or more of their features of climate, vegetation, topography, and soil. These characteristics in their essentials already have been briefly treated under the land types: semi-desert of Maracaibo Basin and the Old Terrace Lands and Filled-in Basins of the Hills and Basins of Lara. Vegetation is generally scant. There are many bare or nearly bare sandy areas and some drifting dunes.

South of this coastal strip is a dry, rolling to hilly, severely eroded country similar to the Severely Eroded Low Hills described under the Hills and Basins of Lara. This belt of eroded rolling country extends eastward from the vicinity of Dabajuro to Puerto Cumarebo on the coast. For the time being it has been included with the Severely Eroded Low Hills of the Hills and Basins of Lara.

Eastward from Cumarebo rolling country continues, but the rainfall is higher and the vegetation and soils are different. Rainfall increases toward the east and the accompanying vegetation changes from thin dry-forest to moderately heavy forest and finally to rainforest, near the mouths of the Tocuyo, Aroa, and Yaracuy Rivers. This Coastal Hill Country extending from Puerto Cumarebo eastward to San Juan de los Cayos, together with the valley of the Tocuyo, is a continuation of the hilly to mountainous area known as the Segovia Highlands. The average elevation, as well as could be estimated, is about 1,000 feet.

From San Juan de los Cayos southward along the coast to the Puerto Cabello-San Felipe Highway is a flat alluvial plain of from 2 to 10 kilometers wide -- wide at the mouths of the rivers and narrower in between -- upstream. Much of this country is heavily forested, ranging to rainforest in places. Other parts are almost bare because of high salinity of the soils. (The soils of these coastal alluvial lands are described elsewhere).

Drainage: In the dry semi-desert and the Severely Eroded Low Hills area the drainage consists of intermittent streams and quebradas. Because of the low rainfall, many of these run continuously for less than 3 months of the year. Others like the Pedregal and the Coro Rivers rise in the highlands to the south and flow from 6 to 8 months, furnishing sufficient water for small-scale irrigation.

Eastward from the Severely Eroded Low Hills area in the higher rainfall belt, the streams are larger and have a permanent flow. The most prominent of these are the Jacura, Tocuyo, Aroa, and Yaracuy Rivers.

Land use and erosion: Considering the area as a whole probably not more than one-tenth of one percent of the land is in cultivation. Most of the cultivation is in a narrow coastal strip from La Vela to Puerto Cumarebo and in the rolling country east from the latter point.

Erosion conditions are just as varied as the topography and vegetation, ranging from excessive in the semi-desert and Severely Eroded Low Hills, where both water and wind erosion are very active, to moderate and severe in the cultivated portions of the Coastal Hill Country east of Puerto Cumarebo.

BROADLY GENERALIZED LAND TYPES OF THE COASTAL REGION OF FALCÓN

Coastal Hill Country (subhumid to humid)

The land type, Coastal Hill Country, consists of hills and low mountains, with intervening strips of river and alluvial flats.

The hills and mountains are rounded, for the most part. Some small areas have a rather rugged or cliff-like character. These are characterized by thin soils and are generally of low agricultural value. Fortunately these rougher areas occur in the heavier rainfall sections, where with proper management forest could be restored or the land planted to grass. Most of the slopes have a gradient of less than 35 percent, with a high proportion of them falling under 25 percent.

Valleys and flats occupied by first bottom and terrace soils constitute about 5 percent of the total area. Although the coastline is somewhat rugged with little or no flatlands, the valleys and upland flatlands do tend to widen out as they approach the shore.

Vegetation changes gradually from west to east, due to increasing rainfall. Beginning at or near Puerto Cumarebo the natural vegetation is a thin stand of forest; toward the east this increases in density and kind until it attains the character of rainforest alcng the Tocuvo River.

The factors of rainfall (amount and annual distribution), slope declivity, depth and texture of soil, transportation and accessibility to market, all have an effect on the value of these lands for agriculture. Considering these factors, it is estimated that at least 40 percent is suitable for cultivation.

Much land cultivated at some time in the past is now in rastrojo. At present probably not more than 5 percent of the entire area is being farmed. Corn, beans, and yuca are the chief crops. Recently, attempts have been made to grow tobacco but the results are not available.

On both cultivated and formerly cultivated land erosion has taken a heavy toll. Many rock exposures are to be seen; much of the country has been so eroded that very little of the topsoil remains. Much good could be accomplished with strip cropping, contour tillage and terracing.

There is reason to believe that this rolling section could be made one of the better farming areas of Venezuela. Cotton, tobacco, corn, velvet beans, soy beans, tomatoes, okra, squash, eggplant, pigeon peas, pineapple, and papaya do well.

A variety of soils occur in the area, the principal ones being the Capacho, Loma, Tucupido, Palacio, Bramón, Guárico, La Cruz, and Guanta groups.

Nearly Level Plains (semi-desert)

The nearly level semi-desert plains sector is a physiographic continuation of the semi-desert type of the Maracaibo Basin. Rainfall is generally lower and the vegetation is more nearly of the desert type.

Farming is of negligible importance, consisting of occasional small patches of corn, sorghum, and ajonjolí (sesame), usually planted in low flat areas along the intermittent streams and quebradas. As an indication of the varying effect

of rainfall, the ajonjoli (sesame) crop for 1942 was reported as an almost complete failure, due to low precipitation during the normal rainy season. Ordinarily this crop does well in this locality.

The region has been heavily overgrazed by goats. Denudation of the vegetation has caused very severe erosion even though the slopes are rarely steeper than 3 percent. Large areas have lost all the topsoil by sheet erosion; others have been severely gullied.

Any reclamation of these abused lands will require drastic measures, principally strict regulation of grazing in an attempt to restore some measure of protective vegetation. Complete exclusion of grazing will probably be necessary for a number of years, plus rigid control thereafter. Cutting of trees for any use whatever should also be very closely regulated.

Drought resistant grasses and sorghums may be grown to a limited extent along the narrow stream bottoms, as well as at the mouths of gullies and quebradas where the waters spread out over the adjacent flats. By use of water-spreading devices and with prohibition of grazing, it is quite possible that native grasses would come back on these areas. The time required is not known.

Along the coast line many areas have been affected seriously by blowing. Huge travelling dunes are continually moving inland from the shores, covering everything in their paths. The largest of these drifting dunes is the one northeast of Coro. This is gradually moving inland toward the city. Some measures have been taken to check the advance but with very little success. Stabilization of these dunes will be no easy matter, but probably could be accomplished through the use of dry-land vegetation, possibly in combination with stakes.6/ Control is particularly important in areas traversed by roads, because the constant work of keeping roadbeds clean by removing the sand involves no little expense. The almost constant presence of dust in the air, during the dry season, may represent something of a health hazard.

Measures of control would involve the building of structures to break the force of the wind, the seeding of drought-resistant vegetation, such as cacti and beach grasses. Wooden stakes may be required to hold the sand of a given area sufficiently steady to allow the plants to establish a root system sufficient to anchor themselves. Not the least important control measure would be exclusion of all animals, not excepting man, from critical points.

The principal soil types are the Cabimas, El Tocuyo, Quibor, Carora, Barquisimeto, Palenque, Coro, and Cumaná groups.

Severely Eroded Low Hills (dry)

The Severely Eroded Low Hills of Falcón are very similar to those occurring in the Hills and Basins of Lara, described above (not shown separately in legend). Land of this kind is characterized by rolling topography and severe conditions of erosion. Large areas of bedrock are exposed. A less eroded area of importance is the coastal strip from La Vela to Puerto Cumarebo. This, although of limited extent, is quite important, agriculturally. Virtually the entire Venezuelan production of aloes is grown on the sandy soils of this area.

Except for this narrow coastal strip, agriculture in the Eroded Low Hills lands of Falcón is of the pastoral type, just as in Lara. Goat raising, with all of its attendant ills, is proceeding steadily, with impoverishing effects on the vegetation, land, people, and goats. Erosion has not yet attained the extremes

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6/ See "Controlling Coastal Sand Dunes in the Pacific Northwest," USDA circular 660, Soil Conservation Service, U. S. Dept. of Agriculture.

observed in Lara, but under present conditions of abuse it probably will not be long in doing so. Remedies and methods of control are the same for both regions.

Soils occurring within the type are the Carora, the Cumarebo, and severely eroded land, which is not a soil but a condition representing the skeleton of a soil.

THE MARACAIBO BASIN

The Maracaibo Basin includes the broad, relatively flat terraces bordering Lake Maracaibo.7/ On the west the area is bordered by mountainous country and on the south by the high Sierra Nevada Mérida Range. On the east side are the highlands of Zulia and Trujillo.

Topography: The surface is predominantly undulating to nearly level. Toward the mountains, especially on the west, more rolling country is encountered. These lands resemble the undulating to rolling Llanos country in the vicinity of Ortiz and El Sombrero, in Guárico.

Drainage: The area is drained by numerous short streams which rise in the highlands to the east, west, and south and flow into Lake Maracaibo. In the northern drier section of the Basin many of the streams are dry for several months during the low rainfall season. The most prominent of these intermittent streams are the Palmar, San Juan, Apón, Pueblo Viejo, and Machango Rivers. In the southern part of the Basin the streams are of permanent flow, the most important ones being the Motatán, Escalante, Chama, Santa Ana, and Catatumbo Rivers. The last stream, although short (about 300 kilometers) is one of the larger rivers of the country. It is navigable for small boats throughout the entire year and for motor freight boats up to about 100 kilometers from the mouth.

Climate and rainfall: The rainfall of the Maracaibo Basin is extremely varied, ranging from 60 to 80 inches in the southern part to less than 20 inches in the northern extremity. The mean annual temperature at Maracaibo is 81 degrees Fahrenheit.

The great variation in amount and distribution of rainfall profoundly affects the vegetation. In the south, between the lake shore and the mountains the natural vegetation is rainforest on the better drained areas and tropical swamp in the poorly drained situations. Northward, the density of growth gradually decreases -- finally to a thin stand of semi-desert scrub trees and cacti. Between these extremes occur various conditions of vegetation, such as average forest, light forest or dry-forest, and savanna.

Land use and erosion: It is estimated that not more than about 2 percent of the basin area is in cultivation, including pastos.

Because of predominantly gentle slopes, water erosion is not serious, generally. Most of the erosion seems to occur in the vicinity of Maracaibo on terrace escarpments. In the drier localities to the north, wind erosion is quite active on the sandy types. Some large dunes have been built up in a number of places.

7/ Strictly speaking, Lake Maracaibo is an arm of the sea or a lagoon. It is roughly bottled shaped, 120 kilometers wide at its widest point and 200 kilometers long from its southern extremity to the Gulf of Venezuela -- to which it is joined by a narrow neck averaging about 8 kilometers in width and about 40 kilometers in length. The waters are fresh in the southern part but become increasingly brackish toward the sea.

BROADLY GENERALIZED LAND TYPES OF THE MARACAIBO BASIN

Nearly Level Plains (semi-desert)

The semi-desert flatlands of the Maracaibo Basin occur in the northern part. They continue along the coast for some distance into the State of Falcón. This coastal extension is discussed under the Coastal Region of Falcón.

The rainfall is about 22 inches in some places and less in other localities. Vegetation is of the semi-desert type, consisting chiefly of cují, cardón, cactus, tuna, and pitahaya.

Land use and erosion conditions are discussed below under the treatment of the Coastal Region of Falcón.

The principal soils belong to the Cabimas and Palenque groups.

Nearly Level Plains (subhumid-forested)

The subhumid variety of the flatlands of the Maracaibo Basin is characterized by a somewhat higher rainfall than the semi-desert variety.

The typical vegetation is moderately heavy forest. Among the common trees are: curarí, penda, indio desnudo, and ceiba. Others are an occasional maya, cují, and cardón. Lianas are abundant.

It is estimated that not more than 5 to 7 percent of the land is in cultivation, including pastos. The chief crops are bananas, plantains, yuca, corn, and gamelote grass. Bananas and plantains are grown chiefly on small included areas in which the rainfall is higher than the average for the type and where the natural vegetation approaches the density of rainforest.

This type of land is generally favorable to an expansion of agricultural activity, particularly dairying. The soils and rainfall are both favorable for the growing of grasses, sorghum, and other feed crops. And the city of Maracaibo affords an important market outlet.

The dominant soils are those of the Cabimas, Ruston, Monay, and Inciarte groups.

Nearly Level Plains (subhumid-savanna)

The savanna phase of the Maracaibo Basin plain is characterized by sandy soils and savanna vegetation. The rainfall seems to be a little lighter than that characterizing the areas of moderately heavy forest. Some small associated areas of clay land are covered by rastrojo.

Most of the land is too sandy and droughty for agriculture, but under good management (Figure 8) is well suited to grazing. Very little farming was seen anywhere. No erosion was observed.

The principal soils belong to the Tamanaco and the Monay groups.

Hilly Benchlands

This Llano-like land type occurs near the mountains west of Lake Maracaibo. It is characterized by undulating to rolling topography similar to that of the Llano country in the vicinity of Ortiz and El Sombrero. The climate is subhumid.

The vegetation is grass -- generally finer textured than that of the typical Llanos -- and scattered chaparro and merey.

Figure 8. -- Good range on properly managed range of subhumid savanna of the Nearly Level Plains country, near Maracaibo.

The principal soils of the area belong to the Guárico, Barinas, and Palenque groups. Along the bottoms of the Cogollo and Apón rivers are strips of alluvial soil: Toa silt loam.

Local areas are seriously affected by erosion, but in general the land has not suffered very much.

Lack of charring around the bases of trees indicates that the practice of burning is not so prevalent here as in the Llanos proper.

The land is suitable only for grazing.

Nearly Level Plains (very humid--rainforest)

This heavily forested, highly humid land of the Maracaibo plains comprises the high rainfall area lying roughly between the southern shore of Lake Maracaibo and the mountains.

Much farming is carried on in the region. It is potentially one of the richest agricultural sections seen by the Mission on its journeys through the Republic. Large areas are suitable for the production of sugar cane, bananas, plantains, rice, corn, leguminous crops, and vegetables. The leading crops are sugar cane, plantains, and bananas. Within the past few years large acreages have been planted to Pará grass for pasturage -- for both milk and beef purposes. Two milk-processing

plants have been established recently; one of them is in production. The output of milk is expected to increase in the near future.

Rainfall is high over most of this variety of the Maracaibo Plain and the dry season is much shorter and not nearly so dry as in most of the country north of the Orinoco. The people of the region refer to the climate as being "always springtime."

Much of the area consists of swamp land and other large tracts are subject to overflow during the heavy rainy season. A large proportion of this overflow water comes from the mountains in which the rivers have their headwaters.

No erosion was seen anywhere, although deposition over the inundated areas indicates erosion upstream.

It is estimated that not more than about 10 percent of the area is in cultivation now. It is believed, however, that the proportion of cultivated land could be increased to 25 or 30 percent of the total.

The presence of wild rubber trees indicates the possibilities of plantation rubber production.

Excellent corn was seen on the natural levees of the Catatumbo River. According to local information, two crops of corn annually is the rule and three crops are not uncommon.

The important soils of this very humid region belong to the Guacara, Encontrados, Uribante, and Maracay groups.

Swamp Lands

Swamp Lands for the most part consist of permanently water-soaked low flats unsuitable in its natural state for cultivation. Their only use is for grazing. With artificial drainage some of the areas would produce corn, rice, bananas, and other moist-land crops. Some of the principal areas, as those around Lake Maracaibo, are so near sea level that drainage would probably be very costly.

THE LLANOS

The term Llanos is used in this report to cover that portion of the lowland country lying between the Northern and Western Highlands and the Orinoco River.

Topography: The Llanos of Venezuela characteristically consist of a broad, level to gently undulating plain, sloping south and southeastward from the northern mountainous country to the Orinoco River.According to the best information available including actual measurements of certain apparently representative areas the region has a gradient of about 4 feet to the mile. The elevation along the contact line with the mountainous country skirting the Caribbean ranges from about 500 to 700 feet.

Locally, remnants of old peneplains are present in the form of mesas that stand about 10 to 40 feet above the general level of the surrounding country. A good example is Mesa Guanipa, in the general locality of Pariaguán and Cantaura (see map). Another local variation is the area of low, flat heavy clay land between El Chaparro and Cachipo, in the State of Anzoategui. This lies slightly below the general level of the Llanos and is usually flooded for a considerable part of the rainy season.

The principal part of the area comprised within the watershed of the Unare River is characterized by forested residual soils overlying soft shale rocks.

This section is generally rolling but on the whole is not much higher than the associated Llanos.

Drainage: The western part of the Llanos, comprising the non-mountainous portions, except stream bottoms and benches, of the State of Barinas, Portuguesa, and Cojedes, together with about one-quarter of Guárico, is drained by numerous large streams tributary to the Apure -- the main northerly tributary of the Orinoco. Most important of these are the Uribante, Suripa, Paguey, Santo Domingo, Raya, Canagua, Boconó, Guanare, Portuguesa, Morador, Ospino, Yaune, Guache, Acarigua, Duragua, Tirgua, Tinaco, Cojedes, Pao Viejo, Chirgua, Tiznados, Guárico and Orituco.

All of these rivers have their source in the highlands to the north as swift mountain streams. In their passage across the Llanos they become more and more sluggish, because of reduced gradient. Some of them divide into distributaries along their lower courses and continue on to the Apure as such or rejoin the parent stream 10 to 100 miles below. Some of the rivers are connected by caños or natural canals.

During the season of high rainfall, a characteristic of the region, these streams overflow their alluvial bottoms. Large areas are flooded for several months at a time along the lower reaches, and travel, except by boat, is virtually at a standstill. On the other hand, the flow is greatly reduced in the dry season. Some of the rivers and many of their tributaries dry up completely.

To the east -- the eastern three-quarters of the State of Guárico and in the States of Anzoátegui and Monagas -- the rivers are fewer and smaller. The main ones are the Unare and Aragua, both of which flow northward into the Caribbean. The Mocapra, Manapire, Iguana, Suata, Pao, Caris, Yabo, Morichal Largo, and Tigre flow southerly or easterly into the Orinoco. The Guanipa, Tonoro, Amana, and Guarapiche flow eastward into the Gulf of Paria. All of these streams except the Guarapiche, Amana, and Tonoro rise in the Llanos. These three have their origin in the easterly extension of the Northern Highlands. Those rising in the Llanos, particularly the Mocopra, Manapire, Iguana, Suata, Pao, Caris, Unare, and Aragua, are very irregular as to flow, often running dry during the season of low rainfall.

Vegetation: The dominant vegetation of the Llanos is grass. This becomes rather tough early in the dry season, but at the beginning of the rainy season and after the fires that burn so much of the region during the dry season the young grass is quite palatable for a time. Throughout the grassed areas occur scattered trees, chiefly, chaparro, merey, alcornoque, and copaiba. Locally 25 to 50 percent of the ground is shaded by trees. Few areas larger than 3 or 4 square miles are free of trees. The section that is most nearly treeless is Mesa Guanipa. This area does not average more than about 2 trees per acre.

From Ortiz to Valle de la Pascua and in the rolling country of the Unare River basin fairly heavy stands of forest occur. Large areas here are covered with thick stands of black cují. These resemble the mesquite of Texas.

In other rather large areas, chiefly those of low elevation and clay soil, palms (resembling palmetto, and locally called palma llanera) occur scatteringly or occasionally in sufficient quantity to be termed palm forest. Most of the streams are bordered with forest that ranges from a mere ribbon of trees to a mile or more in width. Elevation above sea level ranges from sea level to about 700 feet.

Rainfall in the Llanos proper is generally high. Available records show a range from 39 inches at Ciudad Bolívar to 52 inches at San Fernando de Apure. Most of this falls during the six month rainy season from May to October, inclusive. In the rolling basin of the Unare River, precipitation ranges from 26 inches at Aragua de Barcelona to 45 inches at Zaraza.

The mean annual temperature of the Llanos is about 60 degrees.

Land use and erosion: There is very little farming throughout the Llanos, and most of this is concentrated along the streams. In the rolling basin of the Unare, farming is common on the sloping lands. It is estimated that not more than one-tenth of 1 percent of the Llanos is in cultivation.

Cattle raising is the most important agricultural activity in this plains country. The Government is encouraging expansion of the industry by such aids as the building of dipping vats and importation of improved breeds of cattle.

In general, erosion throughout the Llanos is of negligible importance. There are isolated occurrences of serious gully erosion on the mesa escarpments, but these are small and local. Slight to moderate erosion is in evidence on the unprotected cultivated slopes of the Unare River basin. Evidences of slight wind erosion were noticed in the sandy and thinly forested sections of the Llanos.

Agricultural use of the Llanos: Since colonial times the raising of livestock has been the most important industry of the Llanos. Today beef, hides, milk, and cheese account for the greater part of the income of most of the llaneros.

The cattle population has fluctuated widely from year to year. During the war of independence the number of cattle was reduced to a mere fraction of its former importance. With independence established, the industry was revived to a flourishing condition and so continued, with varying success, until about twenty-five years ago, when again it entered a state of decline. Recently, with the building of dipping vats for the control of insects, and with other aids, the industry seems to be improving again.

The frequent burning over the Llanos -- the annual burning, as it really amounts to -- kills some of the ticks, according to the ideas of the llaneros, and also brings in palatable young grass.

There seems to be some grounds for the latter point of view. The old growth of grass is not only tough and unpalatable, but appears to be lacking in nutritive value. At any rate, new grass does come in within about 10 or 12 days after a fire and the cattle everywhere head out of the old grass into the burns. They are reported as gaining weight as the result of this change from grass nearly as tough as wire to grass which for a while is relatively tender and palatable.

As to fires having any very great value with respect to control of ticks, the evidence is not convincing, since the animals seen on the way to market from the Llanos were practically all very heavily infested with ticks. The burning may exert some degree of delaying infestation, but "dipping" certainly is the efficient method for tick control.

As to the effect of burning on the productivity of the soil, very little evidence in the way of quantitative comparative productivity values, as between burned and unburned soil is available. The soils of the Llanos proper are inherently low in productivity. The burning probably has had very little effect on the soil itself, but it may have been the cause of replacing more palatable types of forage with coarse woody grasses which quickly grow into low-value forage. There certainly is no lack of organic matter in the way of coarse grass, but this means little in itself where it is all swept away by the annual conflagration, except that left in the roots.

Among some of the practices that might help to better the cattle industry are: selective breeding for improvement of the criollo (native) cattle for both milk and for beef strains; planting (preferably on plowed ground) of such forage and feed crops as Uba cane, Guatemala, molasses, gamelote, Guinea, Pará, elephant, imperial, and yaraguá grasses, the grain sorghums, pigeon pea, and velvet beans -- in suit-

able localities for grazing and for putting up hay for feeding during the dry season; and construction of more dipping vats for increased dipping. Among some of the questions that should be answered scientifically through carefully conducted experiments are the determination of the pasture and range values of the more promising grasses for the region and the best methods of seeding and grazing; determination of the practical possibilities for producing protein feeds from such plants as pigeon peas, velvet beans, peanuts, and other legumes; development of rotations for pasture improvement; working out methods of beneficial rotation and deferred grazing practices; better utilization of animal manures; possibilities of economic use of commercial fertilizer and lime for leguminous crops; and development of properly located wells or water holes and salting stations.

The farming activities in the Llanos have never been so important as the cattle industry. It is estimated that not more than one-tenth of one percent of the total area is in cultivation. The chief crops are bananas, plantains, corn, cotton, yuca, pigeon peas, beans, and rice. Most of these are grown on the alluvial soils along the streams, except in the section of the Rolling Llanos in the Unare Basin, where relatively large quantities of cotton and corn are grown.

From the standpoint of such physical characteristics as drainage, mechanical condition of the soil, and slope declivity there are extensive areas in the Llanos which are suitable for cultivation. But the soils are not high in natural fertility and for the production of good yields good farm-management practices will be needed.

Most of the Llano soils are acid and lime is needed, especially in growing the soil-improving legumes. Crop rotations including the legumes, and the use of vegetative surface mulching materials in the dry season are greatly needed. Commercial fertilizers undoubtedly would increase yields generally, especially "complete" fertilizers (those containing phosphorous, potassium, and nitrogen), but the cost may prove to be high.

Limestone is abundantly available in various parts of the adjacent mountains on the north. It needs only to be crushed and delivered to the farmers.

In the matter of leguminous crops the pigeon pea is successfully grown in nearly every part of the country. It is well suited to the climate, seems to have a wide range of soil adaptability, adds nitrogen to the soil, and produces good yields. It is an excellent food for both man and beast. Legumes from various parts of the world having similar climate should be tried out locally in order to determine which are best suited to the soils and climate. Among those that might be thoroughly tested are: caraotas, cow peas, soy beans, sword beans (as those which do so well in Cuba), quinchonchos (pigeon pea), velvet beans, crotalaria, peanuts, and both annual and perennial lespedezas.

Both grasses and legumes should be tried on land plowed to depths of at least 6 inches. It is not very easy to break out the normal stands of unburned savanna grass. A double-roller savanna grass cutter, imported from Argentina is reported as an efficient machine for assisting in the plowing of the savanna at the San Carlos Experiment Station.

After plowing these grasslands, crop residues or other forms of vegetation should be carefully tested as surface-mulch materials for conservation of moisture.

The irrigation projects at San Carlos and Guanare furnish an excellent opportunity to conduct experiments on a field scale on several of the most typical soils of the Llanos. The results obtained should be applicable to those portions of the Llanos having similar soil and drainage conditions -- that is, with irrigation.

BROADLY GENERALIZED LAND TYPES OF THE LLANOS

Llanos: Nearly Level (dominant type, humid)

The nearly level type of Llano country consists of broad faintly sloping to undulating plains, normally covered with grass except for scattered trees and clumps of trees (Figure 9). This dominant type of Llano country extends from the base of the Western Highlands southward and eastward to the mouth of the Orinoco (see Land Type Map), with but slight topographic variation. The principal surface inequalities occur as slight local differences in elevation. They are too faint to be noticeable at a distance, but are important from the standpoints of land use.

Very little of this variety of the Llanos is cultivated. The principal crops are bananas (topochos), plantains, corn, pigeon peas, yuca (cassava), sugar cane, and rice. The raising of livestock is the chief agricultural pursuit. Beef cattle and criollo cheese are the leading market products.

Erosion is not a problem of much importance, although some slight damage to sandy lands has been caused by blowing.

The principal soils belong to the Guataparo, Barinas, Ruston, Tamanaco, Canoa, San Tomé, Cachipo, Plummer, Blanton, Palenque, Obispos, Adolfera, and Paya groups. These are described in the following pages. Texturally, these soils range all the way from loose sands to heavy clays. With respect to distribution, silty clay loams and clays are the predominant types west of a north-south line extending from San Jose de Tiznados to San Fernando de Apure. East of this line sandy soils predominate, along with extensive areas of loose sands. Local areas of hardpan or incipient hardpan are of frequent occurrence.

Figure 9. -- Characteristic topography and vegetation of nearly level type of Llanos country, about 30 kilometers north of Ciudad Bolívar, State of Anzoategui.

Along stream courses occur, in strips of varying width, the following alluvial and terrace soils: Tirgua, Maracay, Acarigua, Mene, and La Miel. Practically all the streams are bordered by strips of forest from a hundred feet or so to a mile or more in width.

The forested alluvial lands are the most fertile in the region. According to local information, however, some of the lower lying stream bottoms are subject to such hazardous overflows as to be of little value for crop production. In other places, especially upstream, the lighter inundations will permit cultivation.

Of the uplands or regular Llanos country, it is estimated that about 25 percent is suitable for cultivation with good soil management practices, such as application of lime, use of soil-improving legumes, practice of crop rotation, and utilization of crop residues for surface mulching.

Some of the silty clay loam and clay soils produce good yields the first year in cultivation, but are reported as showing declining yields subsequently. The experience of a farmer with rice growing on San Carlos silty clay loam, near San Carlos, in Cojedes, as reported, is illustrative of this point. In three consecutive years of rice growing the yields were as follows: 3,000, 2,000, and 1,500 kilos per hectare.

Llanos: Undulating to Rolling (humid)

The undulating to rolling type of Llano country is roughly enclosed within the following boundaries: A line extending southwesterly from San Francisco de Tiznados to El Calvario; thence in an easterly direction to a point near Valle de la Pascua; thence northward to San Jose de Guaribe, and westward along the foot of the savanna hills back to the starting point.

The country is predominantly forested. Among the more important trees are the barbacoa, chaparro, alcornoque, amarillo, mastranto, black cují, pilón, jobo, and an occasional cactus (cardón). Many small grassy savannas occur throughout the area. Grass is also plentiful in those areas having a thin stand of trees.

Slopes are seldom steeper than 8 to 10 percent. Extensive areas are underlain by hardpan and sandstone outcrops are of common occurrence.

The principal upland soils are those of the Guataparo, Guárico, Motatán, Tamanaco, and Barinas groups, together with scattered small tracts of Palacio, and Norfolk groups. All of these soils are of water-lain origin except the Guárico, which has developed from a grayish sandstone similar to that which gives rise to the Bramón soils of the San Cristóbal Basin country, and the Palacio which is developed on gray shales. In addition, alluvial soils, chiefly Maracay occur along stream bottoms.

There is not much farming and erosion is not a problem of importance. Farming is of even less importance than on the level to gently undulating Llanos. Bananas, yuca, and corn are the crops usually seen in the patches about the occasional cabins. Small pastures of gamelote and Guinea grass are seen here and there.

Because of the preponderance of very gravelly soils and soils with hardpan in the subsoil, probably not more than about 10 percent of the type is suitable for cultivation. Even this is suitable for cultivation only where the best practices of soil management are followed, such as, use of lime, legumes, crop rotations, and crop residues for mulching. The soils are universally in need of organic matter, such as could be supplied in some degree by plowing under cover crops or interplantings of legumes. Animal manures where available should be used on these naturally thin lands. Lime would also prove of great value in connection with the growing of the legumes. Commercial fertilizers would increase yields and should be used if they could be had at a reasonable cost.

Llano Mesas (humid)

The Llano mesa type consists of nearly level to undulating tablelands standing at an elevation of about 10 to 50 feet above the surrounding country. The type locality is the Mesa Guanipa.

Topographically the surface of the mesas is very much like that of the Level to Gently Undulating Llanos. It had been recognized as a separate class mainly because of soil differences. The soils are more mature in stages of development than those of latter class, and the subsoil generally is more compact. Extensive areas are underlain by hardpan. There are no areas of poor drainage such as those occupied by the Obispos soils associated with the Nearly Level Llanos.

No cultivation was seen anywhere. Gullying was observed on some of the steeper slopes, but it seems to be more of the geological order. Slight wind erosion is in evidence everywhere, but it is not serious because of the prevailingly good cover.

The principal soil groups are: Guanipa, Blanton, and Palenque. Besides these, the organic soils of the Mene group are found in low, wet areas along streams. These water-logged patches are locally known as morichales, because of the almost universal presence of moriche palms.

Because of low fertility, shallow depth to hardpan, droughtiness, and the hazard of wind erosion, this kind of land is appraised as unsuitable for cultivation.

Rolling Llanos (humid)

The Rolling Llanos cover the major portion of the drainage basin of the Unare River. The type consists of undulating to rather steeply rolling land, the latter predominating.

The principal soils are of the Palacio, Loma, Tucupido, Ruston, Blanton, and Norfolk groups.

The Palacio and Loma soils are calcareous in the subsoil and the Tucupido is gypsiferous in the subsoil. All of these are of clay texture and occur over soft gray shales. These three series account for about 75 percent of the total area of the Rolling Llanos.

The Ruston, Blanton, and Norfolk series are of rather loose consistency, quite sandy, and more nearly typical of the true Llanos soils.

In addition, the Acarigua and Toa soils occur as strips of low-lying alluvial along stream courses.

The vegetation largely consists either of rather heavy forest or brush, with scattered patches of grass. Among the trees are black cují, which often occurs in dense thickets, and barbasco, quebracho, guatacaro, cañafístula, uva macho, and an occasional cardón cactus.

About 5 percent of the Rolling Llanos is cultivated. The chief crops are cotton, corn, beans, and yuca. A relatively large acreage has been planted to gamelote and Guinea grasses.

From the soils standpoint, the Rolling Llanos includes the best land in the Llanos. It is estimated that 75 percent or more of these lands is suitable for cultivation -- under good management, such as strip cropping, contour cultivation, terracing, and good crop rotations.

Erosion generally is only slight to moderate on the cultivated land, but a few localities have been seriously affected.

STREAM BOTTOMS AND TERRACES

Nearly every stream in the country is bordered by comparatively narrow strips of recently deposited alluvium. These, generally speaking, are the best crop lands in the Republic, and a large total area is used in the production of sugar cane, bananas, corn, and various other crops. For the most part these lands are well drained during the dry season, but during the months of high precipitation some of the bottom land of the major streams is subject to inundation.

Along the lower courses of some of the major drainages flowing in a southerly direction to the Orinoco and Apure overflows are too violent for the safe cultivation of the land.

Many strips consist of rather high bottom (or low second bottoms: terraces), seldom subject to overflow.

The older stream terraces, which are also generally good crop land extensively cultivated, stand above overflow and are well drained in every respect. Some of them have sand-gravel-cobble substrata so near the surface, particularly in the Llanos, that underdrainage is excessive, causing the land to be droughty and poor for cultivation. These terraces are almost of as common occurrence along the streams as the strips of lower bottoms. They are of older development; some areas have been eroded (mostly geological erosion) to a condition of hilly topography.

There are a number of important areas of alluvial land not cultivated at present that could be successfully used for rice, rubber, cacao, corn, sugar cane, sesame, palm nuts, cotton, and other crops. These lands will give the best average yields generally. They have been hard used in many localities and would be benefited by applications of manure or commercial fertilizer, and with crop rotations including the legumes.

CLIMATE

Although lying entirely within the Torrid Zone and at no place more than 750 miles north of the Equator, Venezuela has a climate that ranges from tropical to moderate. This is due chiefly to wide difference in elevation. Likewise, local variations in precipitation have produced marked differences in the characteristic vegetation of some areas not widely separated. Still other widely contrasting differences in the vegetation and in the productivity of the land were observed from locality to locality, as the result of unwise land use -- particularly the use of excessively steep slopes and failure to use any measures for protecting the land from erosion and excessive loss of rainfall.

Because of climate and land conditions, numerous tropical fruits and vegetables are grown in those coastal areas lying below elevations of around 3,000 feet above sea level. At elevations ranging from about 1,300 feet to 8,000 feet various temperate crops succeed, and from about 8,000 to 11,500 feet potatoes and wheat are successful -- where the soil is favorable. Such fruits as apples, pears, peaches, and plums can be grown if given suitable care, including proper selection of varieties and use of insecticides and plant disease controls.

Both annual and diurnal variation in temperature are narrow throughout most of the Republic. At the higher altitudes diurnal variation is quite high, but at lower levels there frequently is but slight change through the day, and no great change through the year. Of twenty stations reporting temperature data, the highest monthly average is at Coro, on the Carribean coast in the State of Falcón. Here during September and October the average high temperature is 106° F., and the average annual high is 102.7°. The average low temperature is 61° in February, the coolest month. At Caracas, elevation 3,421 feet, the average high is 90° during March and April and the low is 49° in December. At Mérida, elevation 5,291 feet, the average high is 86° in February, and the low is 49° in January. At San Cristóbal,

elevation 3,460 feet, the average high is 88° during March and April, and the low is 54° in January. At Ciudad Bolívar, elevation 177 feet, in the Llanos, the average high is 99° in August, September, and October, and the low is 67° in February.

Table 1 shows the monthly average temperatures for twenty stations. Graph 1 shows graphically the monthly range of temperature for several selected stations.

Venezuela has two seasons: A dry, or summer season, and a rainy, or winter season. The former normally begins about the first of December and lasts until about the first of May, depending on locality. The rainy season covers the balance of the year. These limits vary considerably with altitude and to a less degree with major configuration of the land. Graph 2, showing the monthly rainfall averages for six selected stations, reveals marked variation in dates of rainy season peaks.

Official Government and other reliable weather records are none too plentiful. The several oil companies, the railroads, and a few individuals have kept rainfall records in cooperation with the Federal Government. All records are kept on a daily basis, so that little information with respect to intensity of individual rains is available.

Rainfall data showing monthly averages, together with annual averages, for the most important stations and covering a considerable range of country are shown in Table 2. Map 2 shows the distribution of rainfall.

The highest recorded annual rainfall is at Mérida (elevation 5,300 feet), with an average annual precipitation of 71 inches (20-year record). The lowest recorded annual precipitation is at Cumaná, State of Sucre, where the average rainfall is 15 inches (20-year record).

Many rains are of torrential intensity. They cause tremendous erosion damage to unprotected lands and to highways.

Perpetual snow blankets cover the higher peaks of the Andes, such as Pico Bolívar (16,406 feet) and Corona (16,000 feet) in Sierra Nevada de Mérida. Frost and even an occasional flurry of snow have been reported on Páramo Mucuchies at an elevation somewhere near 14,000 feet (as nearly as could be determined).

Severe overcutting of timber for firewood and charcoal, together with the burning of all the vegetation in field clearings (frequently repeated in second growth -- rastrojo) has denuded much of the high mountain slope land and induced erosion that has converted many areas into a condition of desert or near-desert. This is especially true, for example, of the valley of the Chama in the State of Mérida. Westerly from about Egido for probably 40 miles practically all vegetation is gone, rainfall is light, and the greater part of the land has been abandoned.

The reestablishment of forest cover over these suffering lands should be one of the foremost tasks of the Ministry, and all farmers should be taught to plant trees in every suitable location not required for crops or grazing.

In "Historia de Mérida," Julio Febros Cordero, 1920, quotes from notes made by Friar Pedro Simón telling of a trip through the Chama Valley in 1612 and 1613. According to the Friar, at that time the trees covered the hills and the mountains and the snow line was considerably below the tops of the highest peaks.

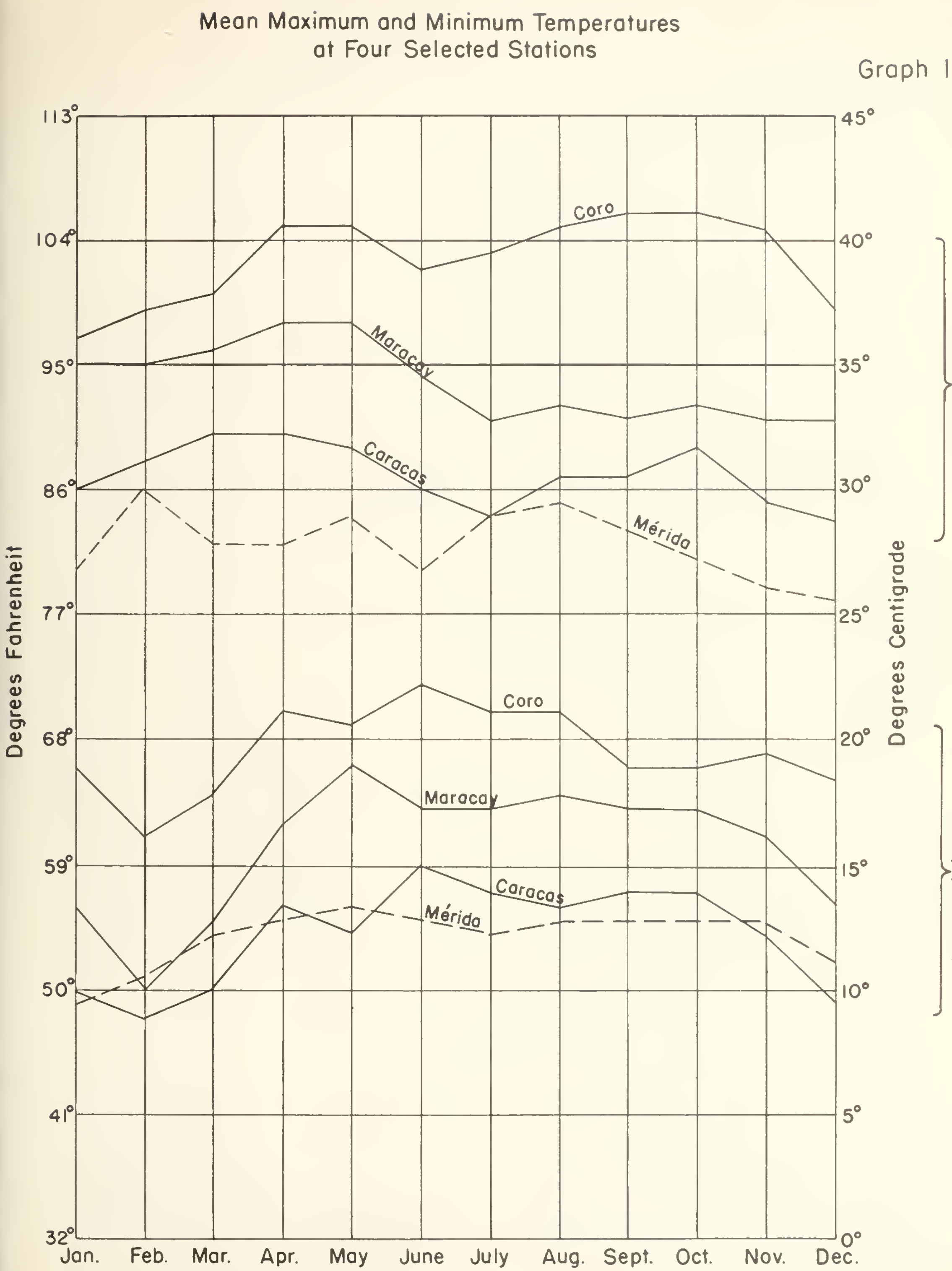
Removal of the protective forest cover, the burning of crop residues, the washing off of the original mellow, absorptive topsoil, the cutting of new water channels by erosion, and the exhaustion of organic matter in the soil by continuous cropping without rotation or application of animal manures or return of organic matter to the soil (as by plowing under vegetable materials of all kinds), are among the injudicious land practices that separately and collectively have served to hasten the run-off and wastage of rainfall. This acceleration of run-off has in turn hastened the

TABLE 1. TEMPERATURES 1936—1941

AVERAGE HIGH AND LOW TEMPERATURES -- FAHRENHEIT

Location	January High	January Low	February High	February Low	March High	March Low	April High	April Low	May High	May Low	June High	June Low	July High	July Low	August High	August Low	September High	September Low	October High	October Low	November High	November Low	December High	December Low
Caracas, Cagigal	86	50	88	48	90	50	90	56	89	54	86	59	84	57	87	56	87	57	89	57	85	54	83	49
Caracas, El Valle	82	45	90	41	90	45	90	50	90	54	85	56	88	52	85	55	86	55	87	56	87	53	84	47
La Guaira	84	68	82	71	84	72	86	73	86	74	87	77	87	77	89	75	90	75	89	75	88	73	86	70
Colonia Tovar	76	39	80	37	80	41	79	45	79	50	74	50	72	50	73	50	75	48	75	47	76	47	74	37
Maracay	95	56	95	50	96	55	98	62	98	86	94	63	91	63	92	64	91	63	92	63	91	61	91	58
Valencia	84	83	88	63	90	63	89	72	88	72	84	68	84	68	84	68	85	68	85	69	86	68	86	63
Barquisimeto	90	63	91	59	93	63	93	64	91	66	90	64	89	64	91	66	91	63	91	66	92	66	90	81
Coro	97	66	99	61	100	65	105	70	105	69	102	72	103	70	105	70	106	66	106	66	105	67	99	65
Maracaibo	97	70	97	70	96	73	97	73	97	72	98	72	97	73	100	72	98	70	98	70	96	72	95	70
Mérida	80	49	86	51	82	54	82	55	84	56	80	55	84	54	85	55	83	55	81	55	79	55	78	52
Bramón (Rubio)	80	51	84	52	83	48	83	58	84	50	80	46	81	45	82	52	84	54	85	56	86	56	79	51
San Cristobal	86	54	87	59	88	59	88	61	86	61	82	57	81	57	85	59	84	59	85	59	86	60	83	57
San Fernando de Apure	98	86	99	64	99	70	100	71	99	69	98	69	95	68	93	68	98	68	97	70	97	72	95	66
Calabozo	95	66	95	70	99	70	99	72	97	72	95	70	93	72	91	70	91	70	97	72	91	72	98	68
El Tigre	93	64	96	62	99	62	99	66	99	68	93	66	95	68	95	66	96	66	98	88	98	89	96	62
Barcelona	93	63	93	64	94	64	96	67	95	67	94	66	93	68	96	68	97	88	96	70	95	68	94	66
Aragua de Barcelona	99	57	97	81	99	83	99	66	101	63	99	68	97	66	94	87	97	65	98	66	97	66	97	63
Ciudad Bolívar	90	68	93	67	95	68	96	70	96	72	93	72	95	70	99	70	99	72	99	72	97	70	93	69
Cumaná	90	63	90	64	93	64	93	68	96	66	93	72	94	71	95	70	94	71	95	71	93	70	91	89
Carúpano	94	65	96	63	96	63	97	68	97	68	98	89	94	69	96	70	98	70	98	71	99	70	94	68
Average 20 Stations	89	59	91	59	92	61	93	63	93	64	90	65	89	64	91	65	92	64	92	65	91	65	89	60

Data from Official Government Publications, Cagigal Observatory


Mean Maximum and Minimum Temperatures
at Four Selected Stations
Graph I
Degrees Fahrenheit
Degrees Centigrade
113°
104°
95°
86°
77°
68°
59°
50°
41°
32°
45°
40°
35°
30°
25°
20°
15°
10°
5°
0°
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Coro
Maracay
Caracas
Mérida
Coro
Maracay
Caracas
Mérida
Mean Maximum
Mean Minimum

Monthly Distribution of Rainfall at Six Selected Stations

Graph

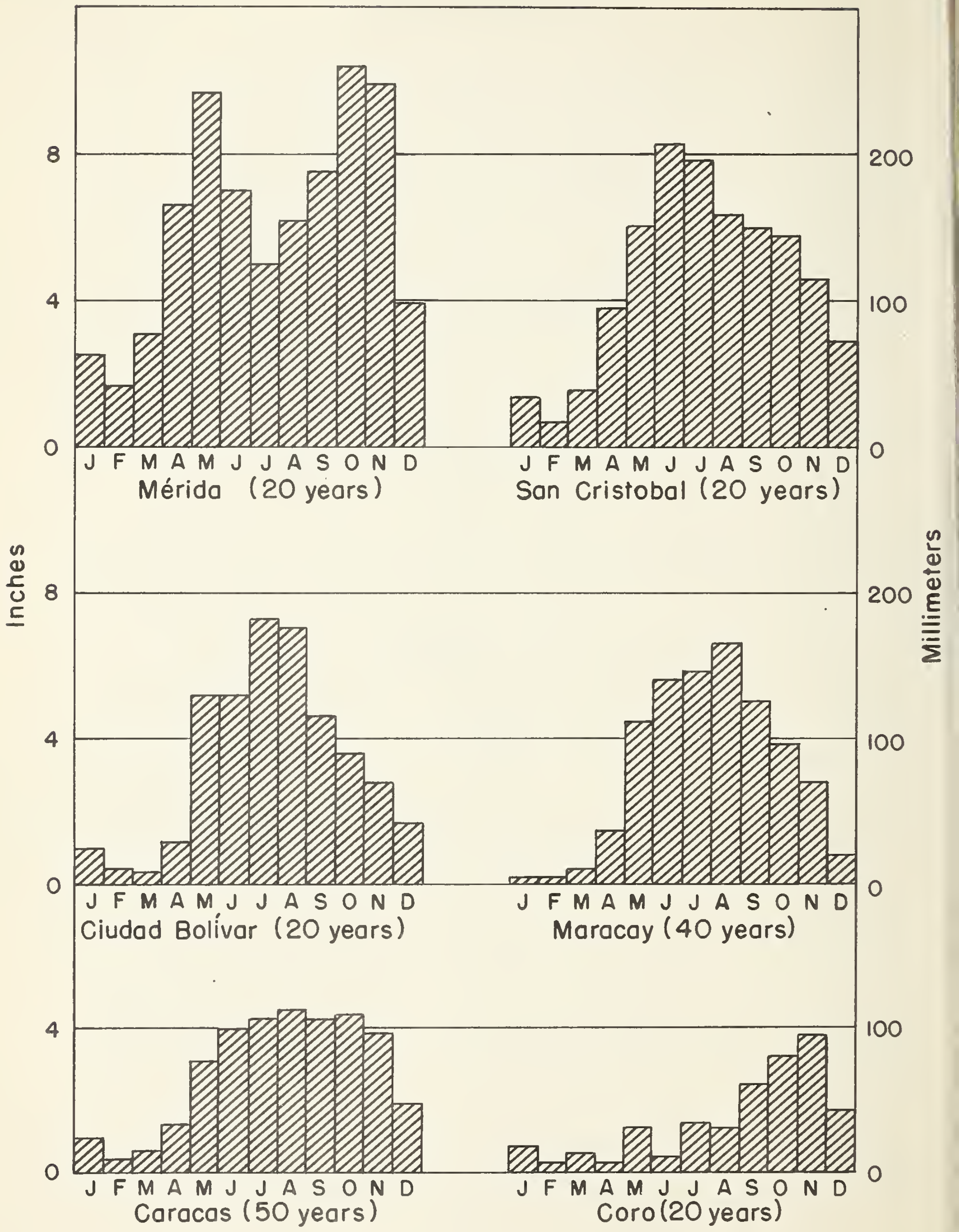


Table 2. Annual And Monthly Rainfall

Location	Yrs. of Rec.	Elevation		Total Annual Rainfall		Averages for designated number of years, in inches and millimeters: Jan.		Feb.		March		April		May		June		July		August		Sept.		Oct.		Nov.		Dec.	
		Ft.	m.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.
Caracas, Cagigal (Obsv.)	50	3421	1043	32.2	825	0.9	23	0.3	9	0.5	14	1.2	32	2.9	76	3.8	99	4.1	106	4.3	112	4.1	104	4.2	108	3.7	95	1.9	47
Caracas, Santa Inez Gran. F.C. de Vz.	40	2914	912	32.9	845	0.9	22	0.4	11	0.4	11	1.5	38	3.1	80	3.9	100	4.1	106	4.7	121	4.1	104	4.2	107	3.9	100	1.7	45
El Valle Agr. Exp. Sta. Dist. Federal	3	3050	930	30.6	784	0.7	19	0.7	19	0.5	13	1.1	27	2.2	57	2.7	70	3.5	91	5.3	136	3.0	77	4.5	116	4.3	111	1.9	48
La Guaira, Dist. Federal	20	32	10	22.1	567	1.2	32	0.9	23	1.0	25	0.7	17	1.5	39	2.2	56	1.5	39	1.5	38	2.6	64	2.1	55	4.0	104	2.9	75
Colonia Tovar, Dist. Federal	10	5897	1798	51.3	1316	1.6	42	0.5	12	1.0	24	2.2	56	5.2	133	4.4	114	6.9	180	7.1	184	5.2	134	7.2	194	6.4	177	2.7	66
Ocumare del Tuy, Estado Miranda	17	689	210	43.9	1125	1.7	45	0.6	15	0.8	20	1.2	30	4.1	106	6.5	167	8.0	206	5.0	129	4.1	106	4.0	103	3.6	93	4.1	105
Tumero Estado Aragua	6	1528	466	41.2	1056	1.8	46	0.7	17	0.2	4	2.4	61	4.4	114	4.8	124	5.6	143	6.1	159	4.7	119	5.7	144	3.3	86	1.5	39
Maracay - Est. Aragua Railroad Station	40	1443	440	35.8	919	0.2	4	0.2	4	0.3	9	1.4	36	4.3	111	5.4	140	5.5	143	6.2	164	4.9	125	3.7	95	2.7	70	0.7	18
Guigue - Est. Carabobo Railroad Station	29			39.2	1006	0.1	2	0.2	6	0.4	10	1.8	46	4.7	123	5.8	150	6.3	162	7.0	181	5.3	136	3.7	97	2.7	70	0.9	23
Valencia - Est. Carabobo Railroad Station	40	1507	478	44.6	1144	0.2	4	0.2	5	0.6	15	2.0	51	5.2	135	6.5	166	7.0	182	7.2	190	5.9	150	5.2	133	3.4	87	1.0	26
Puerto Cabello Est. Carabobo	10	16	5	37.2	955	1.0	27	0.5	12	1.1	29	1.4	35	3.3	85	3.7	95	5.9	151	4.0	105	2.6	66	4.0	104	5.5	138	4.3	106
Pueblo Nuevo, Est. Yaracuy	10			49.9	1280	1.8	47	1.6	40	2.0	52	2.6	64	5.8	147	4.0	104	4.6	180	5.7	145	6.1	160	4.8	122	4.3	107	4.4	112
Barquisimeto, Est. Lara	19	1856	566	18.8	482	0.3	9	0.1	4	0.1	3	1.2	31	2.0	51	2.9	75	2.9	75	1.8	46	1.6	41	2.0	51	2.4	62	0.9	24
Carora, Est. Lara	20	1341	409	25.1	644	0.4	11	0.5	13	1.3	33	1.4	37	1.8	46	1.0	25	1.5	38	2.3	59	2.9	74	5.8	148	5.2	133	1.1	27
Tucacas, Est. Falcon	10	13	4	41.1	1054	2.3	58	1.5	37	2.1	55	2.6	69	1.8	46	2.3	59	2.5	65	2.8	70	2.4	61	5.3	133	8.3	212	7.4	189
Coro, Est. Falcon	20	69	21	16.9	434	0.7	18	0.3	8	0.5	14	0.3	8	1.2	32	0.4	11	1.3	34	1.2	30	2.4	61	3.1	80	3.7	96	1.6	42
Maracaibo Est. Zulia	30	20	6	22.2	570	0	2	0	0	0.3	9	0.7	17	2.4	63	2.2	56	2.0	52	2.2	57	2.9	74	5.6	141	3.2	83	0.6	16
Lagunillas Est. Zulia	10	16	5	36.4	933	0.3	7	0.3	7	1.1	28	1.2	31	4.8	123	2.9	73	4.8	123	4.5	116	4.4	113	7.2	182	4.1	105	2.0	25
Trujillo Est. Trujillo	20	2591	790	57.0	1463	1.4	37	1.8	46	3.3	82	3.6	93	3.8	98	2.3	60	1.7	43	2.9	75	3.4	86	4.2	104	5.2	133	1.8	45
Boconó Est. Trujillo	8	4018	1225	41.9	1075	0.9	23	0.4	10	2.1	54	5.4	137	5.7	147	6.2	158	4.6	117	4.5	114	4.7	120	3.8	99	2.8	72	1.0	24
Mérida Est. Mérida	20	5291	1613	71.0	1821	2.4	61	1.6	41	2.9	75	6.4	163	9.3	239	6.8	174	4.8	123	5.9	153	7.3	187	10.1	258	9.7	248	3.9	99
San Cristobal Est. Táchira	20	3460	1055	53.6	1375	1.4	34	0.7	17	1.5	39	3.6	93	5.9	151	8.0	206	7.5	196	6.2	158	5.8	149	5.6	144	4.5	115	2.8	73
Bramón-Rubio Est. Táchira	5	3870	1180	43.6	1118	2.8	73	0.6	15	3.0	76	4.6	118	2.5	63	2.9	74	6.3	160	4.0	102	2.5	65	4.5	116	7.4	187	2.7	69
San Fernando de Apure Est. Apure	20	223	68	51.9	1332	0.0	0	0.0	1	1.2	26	2.5	64	5.6	143	9.4	215	9.7	249	11.2	287	6.2	160	5.0	130	2.0	52	0.2	5
Calabozo Est. Guarico	19	328	100	49.9	1279	0	1	0	2	0.4	11	2.3	59	6.4	165	6.6	170	9.0	232	9.0	230	7.1	191	4.8	124	3.6	93	0.4	11
Zaraza Est. Guarico	17	196	60	44.6	1144	0.6	15	0.2	6	0.4	10	1.5	39	4.1	105	6.9	177	9.4	241	7.2	185	5.1	131	4.3	110	3.1	78	1.8	47
Ciudad Bolívar Est. Bolívar	20	177	54	38.8	995	0.9	23	0.3	9	0.3	8	1.7	28	5.0	128	5.0	129	7.1	181	6.8	176	4.5	115	3.5	89	2.7	69	1.6	41
El Tigre Est. Anzoategui	10			45.1	1157	0.9	24	0.2	4	0.4	11	0.4	11	3.5	89	6.0	154	7.2	182	8.8	226	6.7	171	5.1	130	4.5	115	1.5	40
Aragua de Barcelona Est. Anzoategui	2	361	110	25.8	664	1.5	37	0.0	0	0.0	1	0.7	17	1.2	32	2.2	57	3.8	97	5.1	130	3.4	87	5.1	130	1.8	47	1.1	29
Barcelona Est. Anzoategui	20	16	5	25.5	653	0.5	12	0.1	3	0.2	5	0.3	9	1.9	49	3.5	91	5.5	141	4.5	116	3.1	80	2.5	63	2.4	61	0.9	23
Maturín, Est. Monagas	19	243	74	45.0	1154	1.6	42	0.8	19	0.8	19	1.5	39	4.1	105	7.1	183	6.7	170	6.4	163	4.6	117	4.2	108	3.7	95	3.7	94
Cumaná Est. Sucre	20	6	2	14.2	390	0.2	6	0.2	5	0.2	5	0.2	5	0.6	16	1.0	26	2.4	62	2.7	68	2.2	56	1.8	45	2.0	52	1.7	44
Carúpano Est. Sucre	20	23	7	35.0	898	1.9	49	1.1	28	1.1	28	1.3	33	2.2	57	5.7	146	5.6	143	4.3	111	3.0	76	2.3	59	3.2	83	3.3	85

Data from Official Government Publications, Cagigal Observatory

process of erosion, and, so, has developed a vicious cycle of soil impoverishment that has led to outright ruin of much land that once was productive or of great value for watershed protection.

The effect of accelerated erosion and the resultant accelerated run-off has been to reduce very greatly the capacity of the soil, or subsoil, depending on how deeply the erosion has proceeded, to retain moisture from the rain in quantities available for plant growth, especially in the dry season. Thus crops suffer seriously in dry weather on severely eroded lands for lack of moisture.

And, insofar as the growth of plants is concerned, the erosion process has brought about on much of the land of Venezuela an unfavorable soil condition which is the equivalent of a change of climate: a condition that results in intensified soil desiccation in times of dry weather that causes suffering of plants soon after the cessation of rains. Thus plants, including cultivated crops and native grazing plants suffer from man-induced change in the plant climate.

With reference to the effect of excessive deforestation on land and water and climate, Pittier says: 8/

> "In none of the Hispano-American countries that I have had the opportunity to visit have I noted as deplorable conditions in the matter of forest destruction and soil sterilization as in the central valleys of Venezuela. And the vandalism of the axe and the fire continues in the country; the denuded area grows wider day after day and if it is not stopped, within a few generations the whole country will be unproductive and semi-desert.
>
> "The contributors to this status are: first, the agricultural practice called 'the conuco, one of the worst heredities left by the aborigines; second, the annual burning of the savannas; and third, the freedom of the goats.
>
> "The conuco farming system consists in felling a virgin forest area, burning the covering vegetation and obtaining few crops of minor fruits and grains. The Indian worked with the sole purpose of securing his existence; furthermore, his operating methods were highly primitive. He scarcely managed to make a hole in the vast forests that covered the country. But the Spanish arrived with the axe, and were not content with little, but destroyed with speculative purpose, establishing vast sugar cane plantations, and in the modern era starting others of great scale: plantations of cacao, banana, and coffee particularly.......
>
> "....the effects of an excessive destruction of the forest are felt in several manners. Besides the impoverishment of large areas that were specially useful for agricultural purposes, there has been an alteration in the climate and the total or partially drying up of the streams. Actually the climate of Caracas is not as it was formerly when there existed the dense forests of the Tacagua Valley and the forests of Catia. In that time, the temperature was more uniform, the dryness of the summer was perhaps not so marked, and the green vegetation was more persistent throughout the course of the year....The topography so much in evidence in Tacagua reveals the presence of deep gullies which could only have been formed by torrents, but which today rarely carry a flow of water. And the Guaire, the noisy Guaire sung of by poets of the past century, is today reduced to a mere trickle of water with occasional heavy floods which are also due to deforestation at its source.
>
> "The same disastrous effects caused by the cutting down and burning of the forests are noted throughout the country.

8/ Pittier, H. Consideration Concerning the Destruction of Forest and the Burning of the Savannas. Boletin, Sociedad Venezolana de Ciencias Naturales, Tomo III, No. 26, Mayo-Julio, 1936. Caracas.

"In the valley of Aragua the watershed has been cleared almost completely and the waters have diminished to the point where Lake Valencia is being reduced little by little to a mere puddle...."

MEASURES FOR TREATMENT OF EROSION

A number of practical measures have proved to be effective in the control and prevention of erosion and conservation of rainfall. The principal measures are: contour cultivation, contour strip cropping, crop rotations, field and pasture terracing, water diversion, water-disposal systems, gully control, contour furrowing, stock ponds, retirement of steep, highly erodible lands from cultivation to the protective cover of trees, grass, or other types of adaptable vegetation, and improvement in irrigation practices.

These measures and treatments are described below, in a general way. All of them will be needed in carrying on an efficient national program of soil and water conservation for Venezuela. Several suitable locations for the application of these measures and practices are pointed out.

Control of Gullies

Gullies are ruining land in nearly every State of Venezuela. They have cut into many fields so deeply and intricately that it has been necessary to discontinue cultivation, even on some fields that were good farm land only a few years ago. Year after year fields are abandoned as the old gullies eat into more of the land and new ones form. The process also develops undercutting trenches along the sides of public highways; undermines road fills, bridges, and culverts; increases maintenance costs; and makes travel unsafe.

Effective control depends to a considerable degree on good land use. This includes retiring to permanent protective cover those areas which are too steep and erodible to farm, cultivation of the less sloping, less erodible lands, and utilization of depressional areas and gullies for the development of water-disposal outlets. Frequently gullies are partly filled in and seeded to grass or other stabilizing vegetation in such a way that they are successfully used for disposal of excess run-off from heavy rains. Cultivated watersheds contributing run-off to gullies must be controlled with such practical farm measures as crop rotations, cover crops, strip cropping, and contour cultivation, alone or in combination with one another and with terracing. Among supplemental mechanical measures are: subsoiling, contour-furrowing or contour-ridging, listing, diversion ditches, and earth fills or dams to impound the water.

These controls are not difficult to install and are very helpful in saving moisture for crops. Where such measures can be used over all or most of the drainage area above the gullies, controls may not be necessary in the gully itself. This is especially true when slopes are moderate and rainfall light.

Where necessary and practicable, run-off should be diverted from gully heads before control measures are undertaken within the gully. Usually this principle applies to gullies of all sizes. In the use of both terraces and diversion ditches (which may differ from a terrace only in length or size) careful consideration should be given to the disposal of the diverted water. If safe disposal outlets cannot be found or provided, the water should not be diverted. Disposal of concentrated run-off on unprotected areas is pretty certain to start gullying.

Any gully, no matter how large, and regardless of its condition, will usually be reclothed with vegetation, provided it is properly protected at the head and is in a situation or locality where vegetation will grow. If the water that causes the gully is diverted and livestock, fire, or any other violent disturbances to vegetation are kept away from the gullied area, the protective plantings quickly take charge of the situation and control it. At first the plants may take hold

slowly because of difficulties in getting a foothold. In some ravines, soil-improving plants, as peas, may be planted to prepare the ground for subsequent plantings to a higher order of control plants, such as grass, or planted to encourage volunteer growth. Such vegetative control measures may take several years in the drier parts of the country, but where there is more rainfall the process is generally more rapid.

Frequently this opportunity to obtain a protective covering is overlooked and unnecessary expenditures are made for installation of dams, conduits, and costly plantings.

Plants usually come in naturally on protected areas but on gullied land several things slow down the final healing of the erosion scars. One is the continued loss of soil caused by direct rainwash and by any water passing through the channel. This loss cannot always be stopped at once, especially where there are exposures of soft materials, but it often can be reduced by the appropriate use of mulches made of boughs, straw, leaves or other available litter. Such mulching assists in catching and holding plant seeds and in increasing infiltration of rainfall.

Another difficulty is the steepness of some gully banks. Until the steep sides, often vertical, cave in and reach a gentler slope (about 1:1 slope), it is difficult for plants to root themselves.

Where natural growths are unable to cope with the conditions or where certain plant species of economic value are desired, it may be necessary to plant the entire gully, without dependence on voluntary revegetation. The kind of vegetation to use is best chosen on a basis of what the planted area will be used for when it is stabilized

Native plants often have the best chance for survival in gully planting, so that they should be given first choice. If local plants are not satisfactory, second choice would then fall on plants introduced from other localities or countries.

In gullies with small drainage areas it is frequently possible to construct fairly effective checks by planting adaptable shrubs across the flow line of the gully or by installing crude brush or rock dams. Such checks reduce water velocities in the channel and induce silting. On these deposits additional vegetation has a chance to become established. The checks should be closely spaced if they are to be effective, and used only in gullies that have an easy grade.

Temporary check dams, whether of planted vegetation, logs, rock (Figure 10), or earth, can thus be used effectively to collect and hold soil and moisture in the bottom of sterile gullies in order to get vegetation established. They may also be used advantageously to check erosion in gully heads or in gully channels long enough for a good protective cover of vegetation to take hold. Piles of closely fitted rock and brush are usually all that is necessary where the run-off is moderate.

Where temporary structures are used to control gullies, it has been found that several low check dams are more desirable than one large dam of equivalent height. Low dams are less likely to fail and after they silt up the vegetation can protect low overfalls from the small dams much easier than the more destructive overfall from greater height.

Brush dams are best suited for gullies with small drainage areas and with soil conditions that permit the driving of necessary anchoring stakes. They are cheap and easy to build. Many kinds of brush dams are in use. The kind to be selected for a particular site will depend on the amount of brush available and the size of the gully to be controlled.

Loose-rock dams are desirable where plenty of suitable rock is available. They are used in gullies of moderate gradient that have small to medium-sized drainage areas.

Figure 10. -- Temporory check dom of loose rock to stop gully erosion by collecting soil for the estoblishment of vegetotion. Neor Aportoderos, Mérido.

The selection of the structure to be used for any particular job is largely a problem of determining the type that will provide the necessary requirements at the most economical construction cost.

Earth dams are used in areas where suitable locations and material for the fill can be secured and where a permanent structure is desired. Besides their control value, they often provide a roadway across deep gullies or a farm reservoir or stock pond -- where locations are suitable and there is need for the roadway or the water supply.

Streambank erosion is frequently associated with gully erosion because it is a channel type of washing. Valuable bottom lands are frequently damaged by bank cutting, particularly along the concave sides of bends of winding channels. The current is directed against these critical points by reason of deflection from bank to bank as the result of the meandering of the channel. The cutting may continue even though the stream is on a stable grade, but generally it is most severe along streams receiving increased run-off from abused watersheds.

Bank cutting on one side of the stream is usually accompanied by the formation of sand bars or silt deposits on the other side. This develops a gradual lateral movement of the main channel. As the process continues, the bends in the channel become more abrupt and the damage to adjacent land more severe.

The success or failure of controlling erosion on streambanks is dependent to

a large degree on the acceleration of flow and the judgment of the technician charged with appraisal of the hydraulic situation and the development of control plans.

Streambank cutting on farms is usually confined to small areas along small streams, some of which flow only intermittently. To control bank cutting on such streams it is generally not necessary to use heavy timber, concrete,or masonry structures -- such as are required ordinarily for adequate control on large streams. The planting of suitable trees, shrubs, and grasses is usually sufficient. Before adequate vegetation can be established it is often necessary, however, to install temporary jetties, wing dams, or other obstructions along the eroded bank to check water velocities and start silting. After the bank cutting is checked and sufficient sediment deposited, the necessary vegetation can be planted in case sufficient cover is not provided by natural growth.

It is especially important that all types of gully erosion controls be protected from livestock. To protect them adequately from damage by grazing and trampling, it is necessary to fence out the animals from the gullied areas. Hogs and goats particularly should be excluded. Vegetation and structures of combustible materials should also be protected from fires. Burrowing rodents occasionally cause failure of structures by digging through them or around the ends.

Failures of erosion controls may result from inefficient installation, from lack of maintenance, or from some extreme condition not ordinarily encountered. These hazards, potentially capable of disrupting at any time the stability of a gully, should be guarded against to whatever extent is practicable. Any damage incurred should be repaired before it leads to further trouble.9/

Tree Planting

The capacity of trees to reclothe and stabilize worn-out land is proved by the forests that have grown to maturity on what was once cropland. In many countries old stone fences are found in the midst of newly grown forests. Once they marked the boundaries of cultivated fields. Now, the remains of corn rows still can be distinguished in the dense second growth covering some of these old fields, abandoned long ago.

In a good forest the treetops usually are close enough to touch and form a closed canopy, and frequently small trees, shrubs, and other forms of lesser vegetation make up a thin to thick undergrowth. Anything less is not considered as first-class forest and is not so likely to provide equally good protection for the land.

The branches, leaves, twigs, and boles of trees expose innumerable little surfaces aggregating, under good conditions, an area several times greater than that of the ground beneath. This loosely thatched roof, often 100 feet or more in thickness, is the forest's first line of protection against soil erosion and excessive run-off. Driving rains beat upon this roof; the raindrops spatter and the water slips gently down the stems and trunks or drips intermittently to the ground.

And beneath, on the ground floor, is commonly found some form of forest litter. Rapid decomposition of such vegetative materials often disposes of much of the ground accumulation in warm tropical forests of high rainfall -- especially in rainforests -- but usually there is some litter, frequently a considerable amount. This ground covering of vegetative litter exerts a powerful protective influence for the soil. In the first place it cuts off direct impact of rain against the soil, and secondly, in thus safeguarding the soil surface from erosion the rain

9/ For further information on gully control see: Farmers' Bulletin, No. 1813, U. S. Dept. of Agriculture -- Prevention and Control of Gullies (prepared by the Soil Conservation Service).

water remains clear or nearly clear. Always, in any soil, clear water seeps more rapidly into the soil; whereas, muddy water produced by soil erosion is slow to enter the soil. The suspended particles of the latter are strained out as they enter the small natural openings into the soil, and so clog these and prevent further intake of the rains.

Thus run-off is increased, since the water cannot enter the soil, and this accelerated run-off, in turn, speeds on the biting, impoverishing effects of accelerated erosion.

In any system of sound land use it is essential that excessively steep slopes, such as prevail in the Andes of Venezuela, be kept in some dense cover, preferably forest or grass.

Successful planting of trees, even on a small scale, is seldom a simple matter. The first, and probably most important step is the selection of adaptable trees for particular sites. Correct determination of the species, size of stock, and cultural practices to be used is basic to successful afforestation. It frequently is necessary to plant, at first, species that may not ultimately occupy the areas to be protected. Unless cultural treatment promises to ameliorate quickly the adverse site conditions, a hardy species better suited to the prevailing conditions should be selected. Such local factors as elevation, exposure, quantity and distribution of rainfall, intensity and duration of sunlight, and intensity, constancy, and direction of the winds must be duly considered. Conditions of slope, soil, and erosion also must be given similar consideration. An understanding of the local indigenous flora frequently offers a useful guide if site conditions have not been materially changed from the original by subsequent treatment of the land.

Where the site has been markedly disturbed by forestry or agricultural operations or by fire (Figure 11) or grazing, remnants of the natural vegetation may be found in protected places. These afford visible evidence of the primitive plant association and often constitute the nucleus from which vegetation spreads to reclothe the affected area. This new vegetation, like the old, struggling against unfavorable conditions, frequently overcomes them and gradually reacquires the characteristic form of the original stand.

Not only are the trees of depleted areas destroyed but the shrubs and perennials as well. The problem of proper reforestation, therefore, may involve reestablishment of the entire flora, beginning with those plants that will lay down an essential ground cover of organic litter and mold. This would require the successful planting of those pioneer species which aid in preparing the land for a higher type of forest.

Every climatic zone has in its flora at least one species suitable as temporary or preliminary vegetative cover, even on poor land. Among the shrubs, the number of species is generally larger than among the trees. Often the most adaptable species for conditioning the site have little commercial value.

It is frequently possible to overcome adverse site conditions by proper preparation of the soil. In some places where erosion has so impoverished the land that only worthless kinds of vegetation will grow, the landowner is neither satisfied to plant species without economic value nor willing to wait on the slow process of natural rehabilitation. It therefore becomes necessary to prepare the land for immediate planting by cultivation, mulching, fertilization, or other means.

Publicly owned forests must be carefully guarded in order to provide protection from destruction by fire. Grazing, especially by goats, must be controlled. Such protection and control safeguard the land against erosion. And forests, thus managed, contribute to the maintenance of stream flows and provide considerable protection from flood. From the standpoint of national welfare, it is important that these public forests be maintained and protected.

Figure 11. -- Successful planting of burned forest area (before and after) Lola National Forest, Montana, U.S.A.

In the Federal District of Venezuela the hills and mountain slopes depict in many places glaring examples of destructive erosion caused by excessive deforestation.

These slopes, according to Pittier, were covered completely with dense forests not more than 105 years ago. The streams had plenty of water at all times. Since then, the forests have been cut off and the land tilled, grazed, and burned over until, today, erosion has stripped off the topsoil and much of the subsoil and has incised the land with numerous gullies. Marked changes have taken place in the type of vegetation. Even desert plants have come into the thin stands of frequently burned rastrojo that now replace the former rich hardwoods.

In many places through the Andes the land is now, or is rapidly becoming, worthless for agricultural purposes and very nearly worthless as a source of water for permanent springs, wells, and stream flows.

Venezuela has before it a tremendous work of reforestation in order to stabilize impaired and wasted watersheds, to revive streamflow, and to prevent further ravaging of lowlands by the debris of wash and run-off from eroding highlands.

Terracing for Soil and Water Conservation

In general, soil erosion may be defined as the loosening and removal of soil from its resting place by the action of wind or water. There are two main classes of water erosion: sheet erosion and gully erosion. The former process involves the removal of surface soil in fairly uniform layers or sheets from entire unprotected fields -- that is to say, a thin layer is removed as muddy water by each successive rain heavy enough to cause water to run downhill. Gully erosion, on the other hand, involves the continuing removal of soil at points of excessive water concentration -- the gouging out of relatively deep ditches into the sloping land.

Sheet erosion may not be as spectacular as gully erosion, but its effects are more harmful because there is so much more of it.

Terracing is a valuable preventive of both types of water erosion. And, as an aid to conservation of rainfall, terracing indirectly helps with the control of wind erosion. Terraces form intercepting channels that break the long sheets of run-off from long slopes into short segments and thereby provide low-velocity removal of excess rainfall (Figure 12 and 13). This materially reduces the amount of topsoil that can be carried downslope from fields in the surface run-off. When placed approximately on the contour, these field terraces hold back run-off long enough for much of it to penetrate the soil. Thus terraces help not only to conserve soil but to conserve needed rainfall.

The employment of any erosion-control measure has as a basic principle, always, the proper utilization of the land. This requires a recognition of the significance of slope, erosion and potential erosion, soil, cover, and rainfall in their separate or combined relationships to continuing crop production. Steep land, for example, cannot be safely used for crop production where erosion proves to be so disastrous that the land is washed to a condition of worthlessness within a few years.

Terracing, supported by necessary cropping practices, is primarily applicable to those sloping lands to be used for crops where other conservation measures will not provide adequate control of erosion. Too often terracing is represented as an alternative to a permanent vegetative cover of grasses or trees. Terraces should not even be considered for land that can be advantageously kept under permanent vegetative cover, except possibly where they may be required for moisture conservation, or diversion of water for gully control on adjoining lands, or as an aid to the establishment of a satisfactory stand of vegetation. Neither can terracing be economically justified on lands that can be adequately protected by proper tillage and agronomic measures, such as contour cultivation, crop rotations, and strip cropping.

The knowledge of both agronomist and engineer is required in determining the

limitations of agronomic control measures and the conditions in each area under which it is necessary to supplement them with terracing.

When properly applied, constructed, and maintained, terraces are valuable conservers of soil on many kinds and conditions of land. They reduce run-off, especially the rate of run-off from small cultivated fields. Combined with other beneficial practices such as rotations within the field (rotations on a contour basis), strip cropping, and contour cultivation, terraces save fertile topsoil and help retain costly seed, lime, and fertilizer. Terracing is an erosion-control measure that has been extensively tested and found acceptable under actual farm conditions, especially when used on adaptable land and in conjunction with other practices of good land use.

Terraces should be so installed as to intercept surface run-off before it attains sufficient quantity and velocity to erode the soil to any considerable degree. They must carry the surplus rainfall from the field at nonerosive velocities and deliver it to stabilized waterways for safe conveyance downslope (so as not to cut out a gully). This is accomplished by placing a series of terraces across the slope where the slope is long enough to require more than one terrace. The first terrace is located near enough the drainage divide to intercept all the run-off from this upper slope before it attains excessive erosive velocity or a volume that will exceed the capacity of the terrace channel. Each succeeding terrace

Figure 12. -- First agricultural terraces for conservation built in Venezuela, near Maracay. Interception and diversion type. Constructed under the direction of the Soil Conservation Mission.

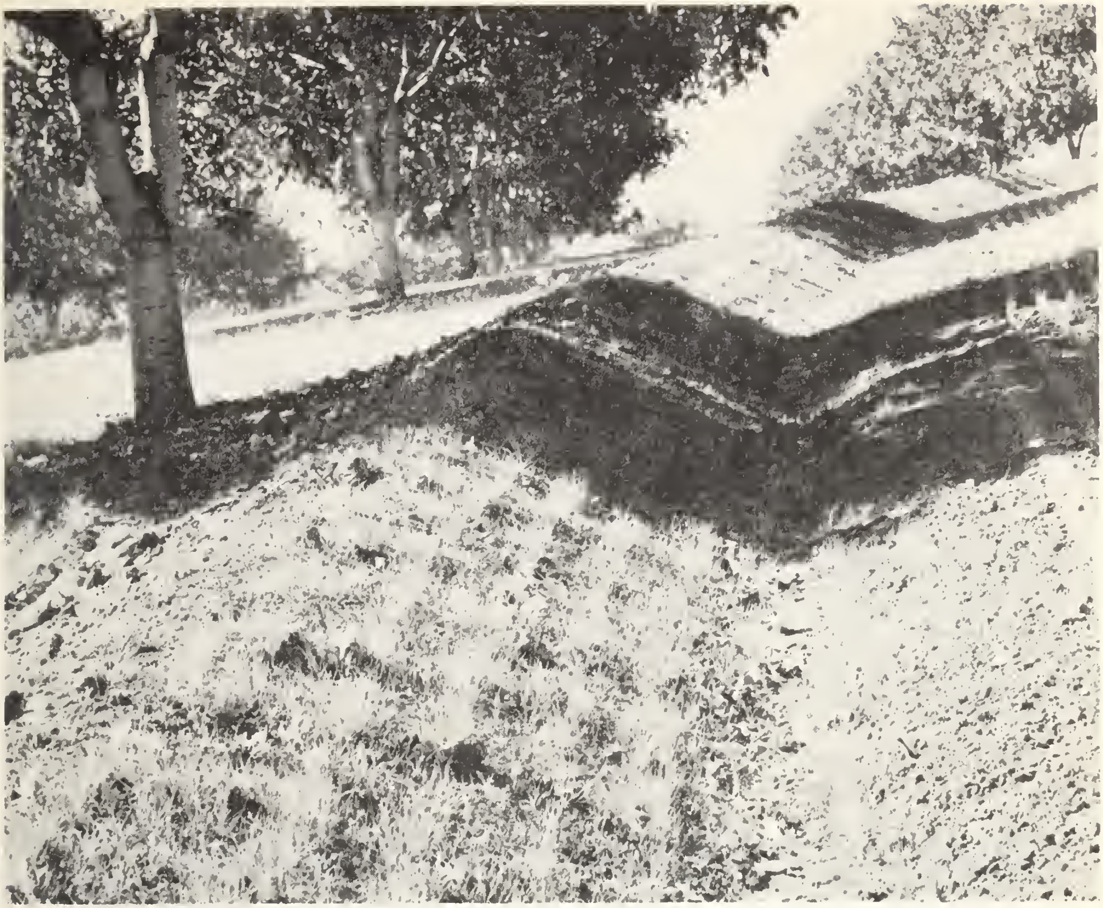


Figure 13. -- Terrace in orchard on steep land. Willamette Valley, Oregon, U.S.A. Interception and diversion type.

down the slope is located in a similar manner. The surface slope, the area (extent of contributing watershed), and the rate and velocity of run-off are therefore the first factors to be considered in the design of a terrace system.

The velocity and the consequent erosive power of the run-off, which increases with both steepness and length of slope, can be checked by decreasing the length of slope. A series of terraces across a slope accomplishes this, for the length of slope in a terraced field (in the practical sense) is only as great as the distance from terrace to terrace. The steeper the slope, the shorter must be the interval between terraces. It is highly important to emphasize the fact, as pointed out above, terraces must be spaced so as to intercept the run-off from the area above each terrace before its erosive power has become great enough to carry away the soil and its volume great enough to exceed the amount of run-off the channel can carry.

Terrace channels of ample capacity must be constructed so as to transport water at nonerosive velocities, otherwise soil may be carried from the channel with the run-off and serious gullying may develop at any point along the terrace line. The velocity in terrace channels increases not only as the slope of the channel increases, but as the average water depth increases and as the surface resistance decreases.

The ultimate objective of all terraces is soil conservation. This objective

is achieved by terraces that provide proper control of the excessive rainwater and increase rainfall absorption -- especially in the control of wind erosion. It seems logical therefore to make a functional classification of terraces: (1) the interception and diversion type and (2) the interception and retention type. 10/

When the construction characteristics alone are considered a corresponding classification would be: (1) the channel type and (2) the ridge type. Classification according to construction should include also a third type, the bench terrace, which is used on steeper slopes.

Cross-sectional dimensions of all terrace types will differ according to slope, soil type, degree of erosion, kinds of crops to be grown, and rainfall characteristics. The kind of machinery to be used in constructing the terraces and in maintaining them may also influence the dimensions of the cross-section.

Interception and diversion type: Since low-velocity disposal of excess rainfall is required, the channel and not the ridge is of primary importance where diversion of excess water is the principal function of a terrace. A wide, relatively shallow channel of low gradient, gentle side slopes, and sample capacity will give the most desirable results. The excavated earth is used to bring the lower side of the channel to a height sufficient to provide necessary capacity. A high ridge is not desirable, since it seriously interferes with tillage operations, increases construction costs, and frequently requires for its formation too much of the productive topsoil scraped from the field. In this run-off disposal type of terrace the ridge should be considered as supplemental to the channel and should blend gradually with the normal slope of the land in order to afford a minimum of interference with machinery operations and to prevent the development of erosion on the terrace itself.

Until the results of demonstrations or experiments prove otherwise, the Soil Conservation Mission believes that the formula $VI = (2 + \frac{P}{4})$ should be used to determine the spacing of this type of terraces. In this formula VI is the vertical distance (vertical interval) between terraces in feet; P is the slope of the land in percent. To convert this formula to the metric system multiply by 30.5--$VI = (2 + \frac{P}{4})30.5$; the VI will then be in centimeters. This formula is the result of many experiments and years of actual use in terrace work in the southern half of the United States and is used by Soil Conservation Service of the United States of North America in its work.

Maximum grades of over 4 inches per 100 feet of terrace length are seldom advisable, since steeper channel gradients usually allow excessive amounts of soil to be washed from the channel.

In the majority of agricultural areas the interception and diversion type of terrace is applicable to the slopes generally considered suitable for the production of cultivated crops under good farming practice (Figures 14, 15, 16 and 17).

Interception and retention type: Erosion control with the interception and retention (or absorptive) type of terrace is accomplished indirectly by water conservation. In order to increase infiltration of rainfall (conserve water) the terrace usually is constructed level with closed ends so as to flood as wide an area as possible with the impounded water. Efficient results require that surface slopes should be fairly flat, the terrace ridge should be of sufficient height to pond water over a relatively large area, and the earth required for the ridge so excavated as to avoid as much as possible concentration of impounded water on small areas.

10/ Soil Conservation, Bennett, Hugh Hammond, McGraw Hill Book Co., New York, 1939. See pp. 443-476.

Figure 14. -- Terrace canstruction with slip scraper - near Moracoy. Constructed under the direction of the Soil Conservotion Mission.

Figure 15. -- Terroce construction with locally made V drog. Near Morocoy. Constructed under the direction of the Soil Conservotion Missian.

Figure 16. -- Completed terrace on San Felipe Experiment Station, San Felipe, Yaracuy. Constructed under the direction of the Soil Conservation Mission.

In this type of terrace the ridge is of greater importance than the excavated channel, which is more or less incidental to the construction of the ridge. Where maximum absorption is desired the terraces must be designed for ample storage capacity and placed on level grades with closed ends. As a factor of safety the ends are sometimes left open so that excess rainfall can escape before the terrace overtops. In some areas the ends of the terraces are partly blocked, depending on the necessity of safety outlets for excessive rains not included in the design frequency. Where impounded water results in excessive crop damage, a slight channel grade, particularly near the outlet, may be necessary.

The retention type of terrace is adaptable to areas of low or moderate precipitation and soils that absorb the accumulated run-off fast enough to prevent damage to growing crops.

The upper limit of land slopes on which this type can be used most effectively for water conservation is, in general, about 3 percent. If used on lands having greater slope the actual area ponded is too small to conserve much moisture unless the terrace ridge is built unreasonably high.

Bench type: Bench terracing involves the building of relatively steep land into a series of level or nearly level strips or steps running across the slope. The flattish strips are separated by almost vertical risers (escarpments), stabilized with rock or a heavy growth of vegetation. This type is known as the bench terrace and exemplifies the original meaning of the word "terrace." It is one of the oldest mechanical methods of erosion control, having been used -- in some form -- for many centuries in thickly populated countries where the population pressure on the land necessitated cultivation of steep slopes. The use of the bench terrace on steep slopes not only retards erosion losses but also facilitates cropping operations on these slopes.

Figure 17. -- Completed terroce system at Mucuchies Experiment Station, Stote of Mérida. Constructed under the direction of the Soil Conservation Mission.

Where it is necessary to use slopes above 20 percent for orchards and the production of farm crops, the bench type of terrace may be efficiently employed, if terracing is required. This type of terrace may be used on slopes ranging up to 25 to 50 percent declivity.

In Puerto Rico bench terracing (Figures 18 and 19) is being used with good success on slopes up to 50 percent or more. 11/ (Figure 19 A)

Terrace construction by farmers: It usually is advisable for farmers who have not had training in the use of surveying equipment and in the planning of terracing systems to have the surveying and planning done by an agricultural engineer or someone who has had the necessary training and experience.

A well-designed system of terraces does not in itself stop all erosion. The success of the terraces depends on whether they are properly maintained and farmed after construction.

One of the most desirable tillage practices for terraced land is contour farming -- the plowing and planting of crops parallel to the terraces. This produces a series of miniature depressions and ridges between terraces, and these aid in moisture conservation and erosion control. Operating tillage equipment parallel to the terraces, particularly equipment that penetrates the soil, also results in minimum damage to the terrace ridge and channel.

11/ See La Conservacion del Suelo en Puerto Rico. Soil Conservation Service, U. S. Dept. of Agriculture.

Good terrace sections can usually be maintained with little or no additional maintenance work if contour tillage and proper methods of plowing are practiced.

In some areas strip cropping is combined with terracing to provide more nearly complete control of erosicn. In most instances the alternate strips of clean-tilled and close-growing crops correspond to the width of the interval between terraces, but it is frequently advisable for the thick crop strip to straddle the terrace. The type of rotations, the crops, and the proportion of each crop to be produced, as well as the kind of land, will determine in part the arrangement and width of the strips.

Some farmers object to terracing because they believe that it interferes with their regular farming operations. At the same time they usually fail to appreciate the fact that the gullies gradually forming on their farms eventually will cause more serious interference with their farming operations than terracing possibly could and that the continual loss of topsoil eventually will render futile their entire farming operations.

Much more satisfactory results with terracing will be obtained if farmers will adopt a policy similar to that followed by highway departments. Both highways and terraces must have good design and construction features and both must be used and maintained according to proved practices. With proper use and care terraces will ordinarily function for many years.

Figure 18. -- Bench Terraces, Mayaguez, Puerto Rico.

- Terracing 12/, strip cropping with or without terracing, and proper crop rotations are likely to have a prominent place in the future agriculture of Venezuela.

Contour Furrows

The principal objective of a soil conservation program on untilled watersheds is to restore and maintain a vegetative cover which will help prevent or diminish erosion and run-off, reduce the hazard of floods in streams rising within the pertinent areas, and furnish a maximum of forage for domestic animals. This often calls for additional improvements, such as fences, stock ponds, corrals, and salting places. In addition, depending on degree of erosion, other treatments such as reseeding, planting, waterspreading, and contour furrowing may be needed to speed up recovery. In the long run, vegetation must assume the principal role of permanently stabilizing the watershed conditions of uncultivated areas. Increased vegetative cover results in increased infiltration of rainfall into the soil and decreased evaporation and run-off from the soil. It also results in an increase of soil organic matter.

Figure 19. -- Bench Terraces - Mayaguez, Puerto Rico.

The point to be emphasized is that supplemental treatment, such as contour furrowing, should be employed only as may be necessary to provide the range with the additional amount of soil-stored water required to produce maximum yield of forage (Figures 20 and 21). Incidentally, of course, such increase of forage (that is, increase of the cover of vegetation) will provide greater efficiency of the watershed in stabilizing flood flows and water supplies.

12/ For further information on terracing see: Farmers' Bulletin, No. 1789, U. S. Dept. of Agriculture -- Terracing for Soil and Water Conservation (prepared by the Soil Conservation Service).

A contour furrow is a groove, trench, or furrow established on gently or moderately sloping land for the purpose of collecting and storing run-off in the soil. The slice, ridge, or dike of soil turned up by the plow or other furrowing implement is usually spread out as much as possible so that the depression is chiefly depended on for retention of water.

Except where constructed for flood control on areas not capable of supporting adequate vegetation for this purpose, contour furrows are ordinarily used as a temporary expedient to hasten recovery of vegetation. Unless the land is properly grazed, efforts expended on range land will be largely wasted.

Furrowing should be definitely limited to areas of fairly uniform topography and to slopes of not more than about 15 percent. No definite type or size of furrow can be recommended for all conditions. Furrows for run-off control should be of small cross-section. Generally the spacing is largely a matter of judgment but as a rule the furrows should not be less than about 6 feet apart. This spacing can be increased to about 25 feet on gentle slopes of highly absorptive land.

Accurate layout and construction of contour furrows is desirable but hardly within the limits of practicability. Depending on the erodibility of the land, guide furrows generally should be run out with a level about every 100 to 300 feet. Cross dikes or dams should be used at about 50-foot intervals where the furrows are continuous. If the plow or other implement is lifted out of the ground at intervals so that the furrow is not continuous, danger of spilling of the water by reason of deviation from the contour is minimized.

Figure 19 a. -- Bench terraces formed of material collected by wash and gravitational creep, between La Grita and Bailadores, Mérida.

Another mechanical operation adaptable to conservation of rainfall is the

Figure 20. Newly plowed contour furrows for ronge improvement, Texos, U. S. A. Stock - water pond in center.

Figure 21. -- Ronge improvement by contour furrowing. Texos, U. S. A.

construction of crescents. These are built by hand or with a plow, scraper, or road blade. They may be a curved furrow about 8 to 10 feet long with the ends upslope, or they may take the form of a gouged-out hole or diminutive reservoir about 6 feet wide, varying up to one foot in depth, with the dirt thrown up around the lower, or deep side, as a dike. An advantage of crescents is that their construction requires no instrumental work. They should not be too closely spaced; always they should be staggered so that the excess run-off will be slowed down by a process of shunting water from one crescent to another.

It is believed that contour furrowing can be used successfully in Venezuela and that the practice should be included in any soil conservation program developed -- for use on adaptable lands. For example, in the State of Lara between Barquisimeto and Carora, contour furrowing could be advantageously constructed on the flat basin lands as a means of conserving rainfall to aid in increasing production of forage.

To be effective, however, control of grazing, especially of goats, would be necessary.

Contouring

Contouring is a term that covers any tillage practice or mechanical treatment of any kind of land, whether forested, cultivated, or used for range, which is applied across the slope on the level -- on the contour. Ordinarily, however, the term is most commonly used for this practice as it is employed on cultivated land -- on row crop land (Figure 22).

Figure 22. -- Conservation of rainfall by contouring (listing). Oklahoma, U. S. A.

Frequently contour cultivation is carried out in terraced fields by running the crop rows parallel to the terrace ridges, thus providing near contour tillage instead of exact contour tillage where the terraces are of the graded type. Where the terraces are of the level type, such procedure, obviously, would give strict contour cultivation.

In general, it probably will be best to run the rows as nearly on the contour as may be practicable. If there is no terrace or other guide line, it will be well to run out guide lines on the precise contour at intervals of about every 100 to 300 feet of slope width, depending on declivity, erodibility of the soil, and intensity of rainfall.

Contouring alone as a practical measure for control or prevention of erosion and conservation of rainfall usually will not provide adequate protection on slopes steeper than about 2 or 3 percent (Figure 23), especially on fragile, highly erodible soil. Where used alone, it generally will not be safe to deviate from the contour more than about 4 to 6 or 8 percent, depending on soil and rainfall characteristics. 13/

Figure 23. -- Contouring gently sloping land near Morocoy.

Reservoirs

Excavated reservoir: Of the various kinds of reservoirs the excavated or dug-out type is one of the simplest to construct. It is the only kind of earth reservoir that can be constructed economically on relatively flat land. Because the capacity of these reservoirs is obtained by excavation their practical size is limited, since earth and rock cannot be moved out of deep excavations cheaply.

Such reservoirs are best suited to those localities where comparatively small quantities of water are sufficient and where impervious soil conditions prevail

13/ For further information on contouring see "Soil Conservation," Bennett, H.H. pp. 434-476, Inc. McGraw-Hill Book Co., New York.

Figure 24. -- Excavated Reservoir (dugout) near Barquisimeto, Lara.

(Figure 24). Since they expose a minimum amount of surface area in proportion to their volume, excavated reservoirs are advantageous in those localities where evaporation losses are high and water scarce. Under such conditions their use enables livestock to drink the greater part of the available water. The ease with which they can be constructed if not made too large, their relative safety from flood damage, flexibility of location, and low maintenance requirements make their use economical, under adaptable conditions (Figure 25-A). One of the chief advantages is experienced in getting livestock to the water without damage to the structure.

Reservoirs of this kind must be properly constructed and located. They must have sufficient depth and volume to provide the necessary water supply, carefully taking into account heavy loss by evaporation (sometimes more than 8 inches a year from a free-water surface). They must be located where the subsoil is impervious, otherwise expensive artificial linings will be necessary to control loss by seepage The drainage area must be large enough to maintain the required water supply and the reservoir must be protected from excessive accumulation of silt. If the reservoir is not located within a waterflow situation, diversion ditches or dikes usually will be necessary to direct run-off into the excavation. Maintenance will involve removal, from time to time, of silt and excessive growths of vegetation.

Dugout reservoirs can be located under rather varied conditions of topography. They generally are most satisfactory, however, and most commonly used where the land is comparatively flat and not subject to inundations of too great volume and velocity. They can be located in broad natural drainageways or to either side of a drainageway from which water can be easily diverted into the reservoir. Those particular spots should be selected which will favor the development of maximum capacity with minimum excavation. Low places, such as a pot-hole, frequently will be good for these structures.

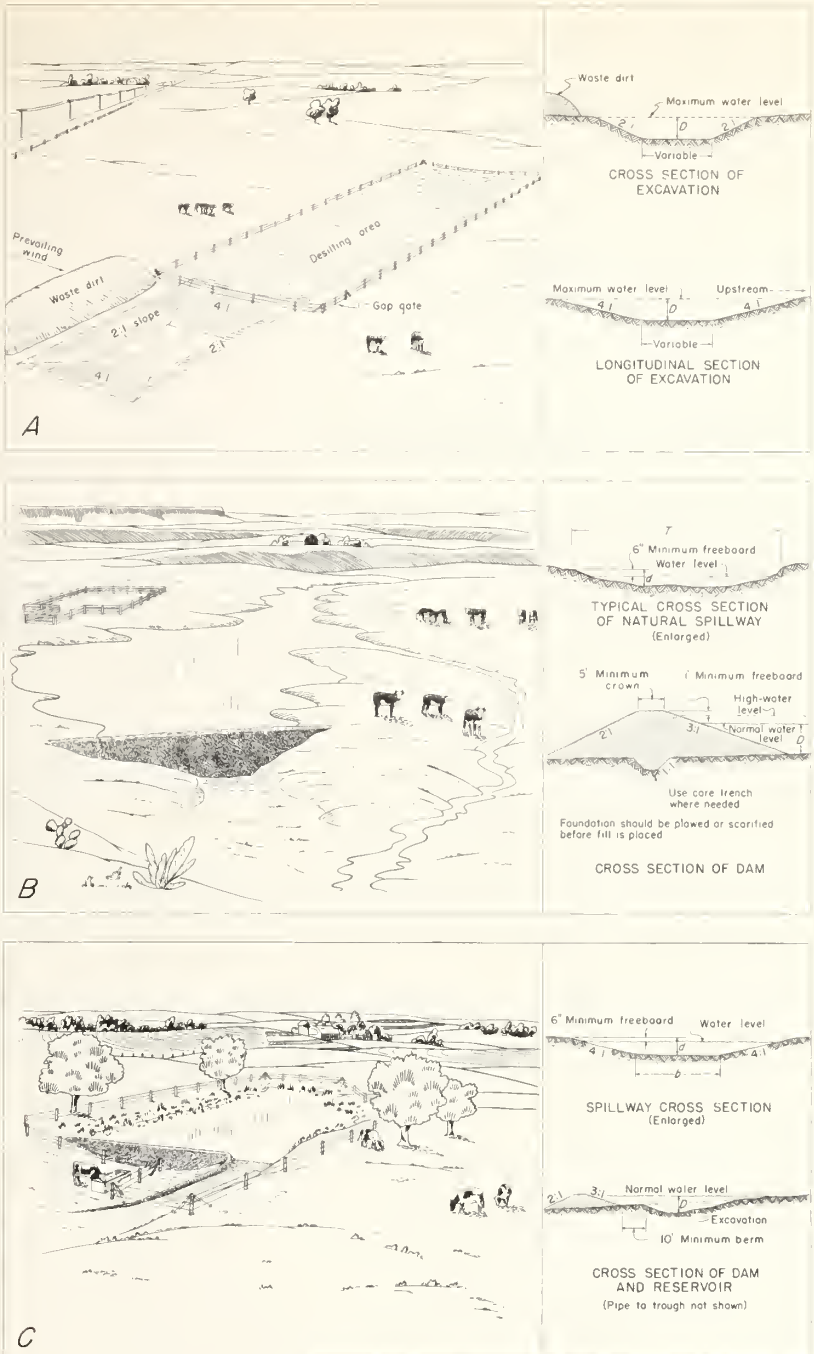


FIGURE 25.--A, Specifications commonly used for small rectangular dug-outs. Note the desilting area used with the dugout. Desilting is desirable in areas where considerable silt is carried in the run-off. B, A stock pond common in the West. Wherever possible, a natural spillway should be utilized. C, A stock pond common in the East. Note the wide entrance to the vegetated spillway.

After the dugout is filled, overflow waters will escape through the normal drainageway. Therefore, those locations having favorable outlets should be selected. Floodwaters are less likely to damage excavated reservoirs in flat terrain because the overflow spreads out and soil scouring or the development of harmful overfalls is less likely to occur. They should not be placed in ground that is too soft because of the difficulty involved with livestock getting to the water.

Dugouts may be circular, rectangular, or of any convenient shape. Custom, excavation equipment, and natural ground configuration commonly determine the shape to be used. A rectangular dugout lends itself readily to construction with slip scrapers and is therefore a popular shape. On flat land the amount of excavation required is practically equivalent to the capacity of the reservoir. On sloping areas the amount of excavation required is usually greater than the reservoir capacity unless part of the excavated material is used to create impounding capacity.

All sides should be sloped sufficiently to prevent sloughing (usually 2:1 or flatter), and one or more relatively flat side slopes (4:1 or flatter) should be provided for livestock entrances. It is desirable to proportion dugout dimensions so that the maximum reservoir depth extends over as large an area of the reservoir as possible.

It is sometimes possible to construct dugouts at comparatively low cost through cooperation with highway departments or contractors. Often these reservoirs can be excavated near highways advantageously. The material excavated is frequently needed for making fills and the reservoir itself will sometimes provide a convenient place to dispose of run-off water.

Impounding reservoirs: The impounding type reservoir (Figure 25B and 25C) is usually constructed by placing an earth fill across a narrow waterway when the volume of flow is not too great. The borrow pit or excavation from which the material for the earth fill is taken can sometimes be used as part of the reservoir.

This type of reservoir is most commonly used. It is particularly suited to rolling land where there are well-defined drainage channels and to conditions calling for considerable storage. Ordinarily, it is more expensive to construct than the excavated type and greater caution is necessary in selecting sites. These must favor the bypassing of flood water safely.

The impounding reservoir requires a protected spillway to bypass flood water satisfactorily. Wherever possible those sites should be selected that have a natural spillway protected with native vegetation. In the absence of such naturally protected spillways, those sites favorable to the establishment of necessary protective vegetation should be given priority. Suitable vegetated spillways must be wide and shallow and must have gentle slopes. A natural swale that will safely bypass the reservoir overflow into an adjacent drainageway makes an ideal spillway. And possibility of diverting reservoir overflow water over a large flat area should not be overlooked. This is not only a simple way to dispose of the reservoir overflow, but it also enables beneficial irrigation of the flooded area -- often the production of extra hay with water that otherwise would have been wasted.

Maintenance of stock ponds: Stock-water developments should be inspected periodically. It is especially important that new reservoirs be examined after heavy rains to determine whether they are functioning properly or need minor repairs. Discovery of damage and immediate repair usually eliminate the need for more costly repairs later. Damage is usually small at first. If neglected, it may increase until repair becomes impractical and the entire structure must be replaced.

In the flat lands of Lara -- the interhill areas -- and several of the other States, there are a considerable number of dugouts and low-level reservoirs. Most of those that contained water in January (1942) were practically dry when seen again in early April. The need for more water for stock in these localities, especially

in Lara, is a very important matter. The Soil Conservation Mission's observations indicate that there are locations other than those in use in which additional structures could be built advantageously.

It is highly important that steps be taken to provide grazing control in combination with water development in much of Lara and in other parts of the country. Little in the way of range improvement can be done until some system is instituted for improvement of the grazing situation. 14/

Contour Strip Cropping and Crop Rotations

The practice of strip cropping has to do with farming across the slope, approximately on the contour, under a system of alternating strips or bands of thick-growing crops with strips of intertilled crops (Figures 26 and 27). The cultivated strips are used for row crops, such as bananas, yuca, corn, cotton, and potatoes; strips of close-growing crops are for the grasses, grains, legumes, alfalfa, peas, etc.

Figure 26. -- Strip cropping with terraces. Texas, U. S. A.

14/ For further information on reservoirs see: Farmers' Bulletin, No. 1859, U. S. Dept. of Agriculture -- Stock-Water Developments -- Wells, Springs, and Pond (prepared by the Soil Conservation Service).

With this system the widths of the cultivated sections of fields are narrowed and the alternating strips of sod or grain or peas or whatever thick crop is grown, tend to slow down the speed of run-off water and to catch or filter out the load of soil that may be carried in suspension by the water running out of the cultivated strip above. Both the velocity and quantity of run-off water passing through the thick crop is reduced and for that reason more of the water enters the soil. Then the crop rows on the level (the contoured rows) catch and hold back still more of the water, allowing it to soak into the ground.

Figure 27. -- Strip cropping. New York State, U. S. A.

Experiments in some localities have shown that cultivation on the contour sometimes reduces soil losses by as much as 50 percent and water losses up to 30 percent.

The width of the strips is very important. Within practical limits, the oftener the slope is broken by a strip of an erosion-controlling crop (a thick-growing crop), the more effective is the control of erosion. Proper widths of strips will vary considerably with the slope (Figure 28) and to a less degree with the soil. Generally, thin eroded land should have narrower strips than deep, absorptive soils well supplied with organic matter.

The management of strip-cropped fields involves principally the establishment and arrangement of crop rotations for the most effective erosion control. Any plan should include a rotation of crops to keep the soil productive, and it is expected that the close-growing and the cultivated crops will alternate according to a planned cropping system. For example, a strip of Guinea grass may remain on the same strip of land for two or three years, according to the plan, and then be plowed up and

followed by a row crop. The area formerly occupied by the row crop would then be seeded to a close-growing crop. A strip of corn, yuca, or other intertilled crop should not have cotton, potatoes, bananas, or other intertilled crop planted on the adjacent strip.

Even with well-managed strip farming water may gather in depressions and cause gully erosion. Waterways should be wide enough for disposal of excess run-off. Narrow grassed waterways tend to erode along the sides.

Contour strip cropping is not a substitute for terracing. It should be used alone where terracing is not needed or cannot be effectively established, and should be supported always by contour cultivation. Where terracing is needed, the ideal arrangement is to terrace the land, then follow with strip cropping to supplement the terracing.

Where farms are small and practically all of the land must be used for row crops, a modified system of contour strip cropping is sometimes rather effective. This consists of planting narrow contour strips of such grasses as Guinea, elephant, or Guatemala between the strips of intertilled crops.

Strips should be rotated each year, if possible. Where alternate strips are in corn and pigeon peas one year, the year following should find the order reversed, peas or alfalfa or some close-growing crop should be in strips where corn grew the first year, and vice versa. 15/

Figure 28. -- Strip cropping on steep slope. Tennessee, U. S. A.

15/ For further information on strip cropping see: Farmers' Bulletin, No. 1776, U. S. Dept. of Agriculture -- Strip Cropping for Soil Conservation (prepared by the Soil Conservation Service).

Figure 29. -- Irrigation following closely the contour of the land - in Utah, U. S. A.

Irrigation

Irrigation is a very old practice in Venezuela. Irrigation systems built several hundred years ago are found in the Andes; some of those installed during the days of Spanish colonization are still in active use.

Modern irrigation is being installed throughout the Republic of Venezuela as funds are made available. At present (summer of 1942) new projects are being delayed somewhat because of the scarcity of certain construction materials.

The engineering design, as well as the construction, of all the irrigation projects observed by the Mission were very good. In addition to the actual irrigation works, homes for farmers have been built on these projects, as well as buildings necessary for maintenance and administrative purposes.

The soil Conservation Mission did not attempt to make detailed studies of these projects, but at the request of the Minister of Agriculture several of the projects were visited to determine the suitability of the land for irrigation agriculture. Such studies were made in detail of the projects at Barcelona, Valencia, and San Carlos, and the results and recommendations were transmitted to the Ministry.

The combined Barcelona, Guanare, San Carlos, Valencia, and Mototán River projects will provide approximately 156,000 acres of new agricultural land. On these areas various crops can be grown, such as sugar cane, cotton, corn, rice, vegetables, and bananas. All the projects are reasonably close to good markets: Valencia Maracay, Caracas, and Maracaibo.

These developments should materially help the food situation and reduce the necessity for importation. Two additional large projects are proposed: One north of Maracay and the other east of Lake Valencia. The former will use the Limon River

for storage and provide irrigation water for a large acreage between Maracay and the mountains. The other project will utilize the waters from the Turmero and Aragua Rivers to irrigate a large acreage suitable for many crops. In both, much of the soil is very fertile and well suited for agriculture.

It is probable that other suitable sites can be developed in the upper Llanos along the southerly toe of the Andes in the States of Portuguesa, Barina, and Táchira.

Because of the apparently plentiful supply of water for many local mountain irrigation systems, especially around Bailadores, State of Merida; along the Carache River in Trujillo; and in the upper valleys of the Aragua and Manzanares, in Monagas and Sucre; irrigation practices are wasteful of water and damaging to the soil. Main ditches and canals, together with the lead-off canals, have been constructed on grades that are too steep. These develop high water velocity and, as a consequence, increased erosion. Most fields are cultivated up and down the slope, whatever the gradient; and wherever high velocity flows are turned into crop rows of too steep declivity the good topsoil is swept away at a rapid rate.

Around Bailadores several improved methods of cultivation are being practiced on a number of farms. Cultivation and row direction have been changed on some farms from up and down the slope to across the slope. Unfortunately, the rows are still held to straight lines, so that proper balance between slope and velocity has not been attained, especially in those fields of varying surface configuration.

Increased attention should be given this problem of field layout. Cultivation and rows should follow the contour of the land more closely. Farmers should be shown how crop rows can be laid out with a simple tool, such as a level-board, on grades low enough to slow the flow of irrigation water sufficiently to cause most of it to sink into the ground. The rows should be laid with very slight gradient around 2 percent -- so that they can be plugged or dammed at the end away from the head ditch. The row can then be filled and plugged at the entry so as to allow the water to stand long enough to be absorbed by the soil. By this method very little water is wasted and removal of soil from the fields by erosion is greatly reduced. Farmers, whether irrigating or not, should get away from the old idea that good agricultural practice means farming in straight lines.

The Ministry of Agriculture probably could advantageously employ one or two good irrigation engineers, not to design and lay out the large irrigation systems, but to work with the farmers to improve irrigation practices. This would include revision of fields, relocation of head ditches or establishment of new ditches, and introduction of near-contour application of water (Figure 29). Where irrigation by field flooding is used, it would be necessary to change the size and shape of fields and to establish new borders and border dikes.

In most of the irrigable country, rock is plentiful. Thus it would be possible to reduce ditch erosion by the use of stone check dams, drops, or overfall structures. These can be installed in the main canals and in the laterals. Drops constructed of stone can be used to let down the water directly to fields or low levels, to reduce the rate of flow, and to provide better control of water delivery and other aspects of handling water.

Flood irrigation is practiced in many parts of Venezuela. Because of torrential rains diverted flood water can do tremendous damage to the lands to be irrigated unless great care is used in both the design and layout of the diversions and spreading system. Diversions and collector dikes are being effectively used for filling stock ponds. Diversions for take-out ditches from roadside drainage are easily constructed and are effective for flood irrigation and filling ponds. There are many valley areas -- mostly alluvial land -- where small areas can be used for the growing of crops by the use of flood irrigation.

It is believed that flood irrigation offers considerable opportunity for in-

creased production of food crops. The Ministry of Agriculture should make a survey of the lands of the country to determine which are irrigable and can be developed along practical lines for the use of some of the steep-land farmers of the mountain areas.

In the low flat plains or interhill country, of Lara small crescent-shaped dikes favorably located would retain a great deal of run-off if enough of them could be built. This would allow time for the water to percolate into the soil for crop use. Probably these would be more effective than a series of dikes.

SUGGESTIONS FOR AGRICULTURAL RESEARCH AND DEMONSTRATION

Effective research and demonstrations of proved practices are helpful in developing good land use and adequate land protection, the basis of successful agriculture.

For effective results a research program should be carefully planned and scientifically carried out. Such a program should be based on the major agricultural needs of the country and should be so conducted as to provide every possible aid to the solution of every important problem having to do with the agriculture of the various distinct regions of the nation.

Among the principal problems needing the scrutiny of research in Venezuela at this time are those relating to the process of erosion, soil and water conservation, adaptable crops and crop varieties, beneficial rotations, improvement of crops and animals through selection and breeding, improvement of cultural practices, improvement of agricultural machinery, improvement of dairying, development of refrigeration and storage facilities at strategic points throughout the country, betterment of wildlife conditions, the economics of farming, social conditions and needs of farmers.

Since agricultural practices now in use are in many instances promoting excessive soil erosion, it is essential that methods be developed whereby all farm land can be protected against this menace. On numerous slopes soil productivity has declined severely because of erosion. Extensive areas have become very poor or worthless because of soil decline through sheet washing and gullying, and the people cultivating such lands are suffering the consequences. Large areas that formerly were cultivated have been abandoned, and those who tilled the lands went elsewhere for a new start in line.

Steep slopes that should be left permanently in protective forest have continued to be cleared for cultivation and are permitted to wash disastrously. Gradually more land becomes unfit for crop production and is abandoned. (There is a limit to this practice, however, in the area north of the Orinoco, because the remaining stands of real forest are now very limited).

At that stage of land depletion marked by deep gullying or exposure of rock and the deeper stratum of subsoil, it is often difficult to reestablish a worthwhile forest growth or any other type of useful vegetative cover.

Usually, however, those areas that lie within the humid zone can be forested in some degree or regrassed. Venezuela generally has a wide adaptation to grasses, so that where rainfall is sufficient useful vegetation of some kind can be utilized for stabilizing severely eroding lands. Also, nature without assistance -- indeed under such severe restraints as annual burning -- somehow manages to restore a protective cover of some sort -- weeds, grass, or brush -- under conditions of good rainfall. This second (or third or fourth, etc.) growth is known as rastrojo (Figure 30). Land is seldom abandoned because of the essential exhaustion that comes from continued cropping without return of organic matter or manures of any kind. Cultivation is continued sometimes even when the yields have declined to 2 or 3 bushels of corn or 1 or 2 bushels of wheat per acre.

Figure 30. -- Rastrojo, Venezuela

Effective use of land -- use according to the capability of the land to produce under good management, including protection from erosion -- should be a guiding principle in all investigations and demonstrations in the field of practical farming operations. Wise use of water and both natural and planted stands of vegetation should also be a guiding principle.

Experiment stations have been established in many parts of the country. In most instances the locations for the stations were well chosen, so that, with few exceptions, each is representative of important land and types of farming for particular regions. Enough progress has been made to indicate that there are many worthwhile opportunities for improvement of the agriculture of the country. This is emphasized, for example, by the work being conducted with sesame, corn, and castor beans. This work has been outstandingly successful and will doubtless attract wide attention.

Particular effort should now be made to improve the varieties, cultural methods, land selection, and land improvement and protection in connection with the production of rice, potatoes, fats, fibers, legumes, fruits, wheat, dairy products and other subsistence crops. These are products that are greatly needed in increased amounts.

Production of these items undoubtedly can be increased through the use of better cultural practices. Some farmers have proved this in producing some of these commodities. Information on improved methods should be disseminated to farmers throughout the nation, it is believed, by means of adaptable field demonstrations. As new information is developed through research and farmer experience, and as improved varieties of crops become available, the facts could be carried out to the farmers very advantageously in this manner (Figure 31).

Thus, demonstration farms would be of inestimable value in the dissemination of research and practical information as it becomes available. It might be helpful to tie in such a demonstration-unit program with each experiment station. Some demonstrations could be established in localities where there are no experi-

ment stations, especially for showing the farmers how to make greater and more efficient use of available agricultural information. For example, the Soil Conservation Mission during its rather brief stay in the country demonstrated the practical use of a number of erosion-control practices in several of the States west of Caracas. Additional demonstrations probably could be advantageously carried out in other localities.

The Agricultural Agents could make special effort to acquaint farmers with erosion-control practices, urging their adoption as rapidly as possible in those localities where erosion is becoming a serious problem.

The Mission observed the work of a number of experiment stations and examined some of the station reports. On the basis of these more or less superficial observations and studies several suggestions are presented below with the hope that they may be useful in extending the national research program:

It is believed it would prove helpful to establish some centralization of agricultural research activities in the Ministry of Agriculture and Animal Husbandry. Experienced, well-trained technicians should be given authority to develop adequate programs of research and demonstration for the country in such pressing activities as good land use, including protection of the land from erosion, improvement of field practices and animal husbandry, development of refrigeration and storage facilities for farmers, dairymen and ranchmen, and location of suitable areas for relocation of submarginal farmers and development of practical methods for effecting satisfactory relocations.

Figure 31. -- Field day - demonstrating the use of a bottle level for laying out contours. Mucuchies, State of Mérida.

Competent superintendents should be placed in charge of each experiment station. Such specialists should be well trained in research technique, and they should, of course, be thoroughly competent to direct the particular type of work which is to be emphasized in the selected locations. If the station is a large one, with a diversification of problems, it is felt that additional specialists should be assigned to special problems falling in the various fields of agricultural sciences.

As is always necessary in scientific investigations, great care should be exercised in the selection of the technical personnel, since the success or failure of programs will depend to a very large degree on their competence, energy, and inclination toward sustained effort. Capable technicians performing work of this nature should be afforded sufficient security to feel that they may be permitted to remain in their positions as long as they render efficient and satisfactory service. The appointments should be on the basis of ability.

A well-defined, adaptable research program should be developed for the country as a whole, for each distinct agricultural region, and for each station. The entire program should be properly coordinated, so that the work at each station fits into the general program, with least possible duplication of effort and expense.

The work at each station should be covered by a carefully developed set of work plans. Such plans should be proposed before the work is started, and they should each have the approval of the appropriate branch of research at the Ministry in Caracas. Such approval would carry assurance that the study is essential, that the technicians are qualified to handle the work, and that the procedures to be followed are satisfactory. This assurance would, of course, not overlook the absolute necessity for a system of proper checks and replications adequate to insure soundness and practicality in the conclusions to be drawn from every completed experiment. Important changes in work procedures should require headquarters approval.

omit

Such procedure would help with the development of sound programs and give essential continuity to the work.

At some of the stations it appears that when a new superintendent is assigned to the station, the tendency is to discontinue all or most of the work already under way and begin all over with a new set of studies more to the liking of the new man. This means the loss of much effort and time.

omit

Both research and demonstrational programs should be operated in a systematic manner, and records should be required of every project, including progress reports on an annual basis at least, and, when the work is done, final reports. It is not possible, as a rule, to obtain conclusive results in a year or two. Some lines of investigation may require a period of years, or a cycle of climatic conditions, in order to acquire adequate information on the subject.

It is always advisable, of course, to encourage initiative among the technical workers, but there must be some check on their enthusiasm in order to assure continuance of studies to completion, accuracy as to methods at all stages, and soundly-drawn conclusions at the end.

The development of work plans would require that the station director and his aides study the methods used in previous work on the station; examine the physical aspects of the station -- its lands, equipment, and working facilities, and to think through plans and objectives for the future, based on the more pressing needs of the local farmers and of the nation.

Such plans would also furnish a permanent record of each project, with all procedures given in detail, so that if a change in personnel should occur, the work could be continued without serious interruption. Moreover, such a set of plans would enable the Ministry to keep informed of all work being carried on, and to coordinate the national program as a whole. It would provide a logical basis for

preparation of progress reports, and prove helpful in developing a sound arrangement for budgeting and allotting funds and keeping accounts.

At each station a complete record should be kept of all operations and practices, covering tillage methods; dates, rates, and methods of seeding; varieties or strains of all plants grown; dates of cultivation; condition of crops at different stages of growth; yields; quality of crops; and other pertinent data. Where animal-husbandry or dairy-industry projects are under way, very careful records should be kept covering lines of ancestry of breeding animals, feeds and feeding rates, weight gains, production data, etc.

Weather records should be kept in such manner that accurate readings are promptly recorded, without chance of missing a single weather record at any time. Rainfall, temperature, and humidity would constitute the principal records.

Where practicable, quantitative data should be obtained with respect to the protection afforded by different crops and tillage practices against soil and water losses. Visible results with respect to such losses, as those obtained at soil and water conservation experiment stations, could be effectively used as a part of the educational program. 16/

omit: insert attached paragraphs

~~Experiment stations should not be required to show an operating profit. Research is often tedious and somewhat expensive. Considerable money may be required to equip and operate laboratories from which no direct income is received. Much time and effort may be spent improving certain species of plants, or types of animals, which may result in greatly increased income for farmers, but the station cannot afford to waste the time of highly trained technicians in simply operating a profitably producing farm.~~

~~Some of the stations visited by the Mission seemed to be especially interested in realizing dividends in money instead of in information that would help the farmers of the country.~~

A well-organized demonstration program should be carried on in conjunction with research. A demonstration field or farm should be a part of each experiment station, and additional demonstration areas should be established in easily accessible places where the need exists. Here, improved agricultural methods appropriate to the region would be put into actual practice, under practical farm conditions. New crops adaptable to the locality by station tests, and proved soil and water conservation practices would be demonstrated as to adaptability and practicability.

PROPOSED OUTLINE OF WORK PLAN FOR RESEARCH STUDIES

TITLE: This should be brief but in specific terms adequately explaining each study or project to be undertaken.

LOCATION: Give exact location of station, together with home address of superintendent. On a good base map of the station show precisely where the work is to be done.

OBJECTIVE: Give a clear and complete statement of the objective or objectives of the study -- the purpose of the experiment.

PREVIOUS WORK AND JUSTIFICATION OF THE STUDY: Briefly review the literature, if any, dealing with each study or project, giving a summary of the agricultural problems involved and reasons why the study is proposed.

16/ See Soil Conservation: Rates of Erosion and Run-off, pp. 125-168, inc. Bennett, H.H. McGraw-Hill Book Company, New York.

Experiment Stations should not be required to show an operating profit. Research is often tedious and somewhat expensive. Considerable money may be required to equip and operate laboratories from which no direct income is received. Much time and effort may be spent improving certan species of plants, or types of animals, which may result in greatly increased income for farmers, but the station cannot afford towaste the time of highly trained technicians in simply operating a profitably producing farm. Although it is not the policy of the Venezuelan Experimental Institute of Agriculture to operate the bona fide expriment stations at a profit, it was found in several instances that the station directors were emphasizing the profit side of the work.

Demonstration farms may be operated at a profit, and in many cases the additional information gained with regard to profits may add substantially to the value of the demonstration. Whether or not a demonstration should be operated on a profit basis will depend on the locality and upon the advice of the economic adviser. In a community like Merida where the farmers are interested in farming techniques and where they have a good marketing system, it is believed that seed distribution and even the distribution of animal sires would be better for the people than a pure demonstration of profit farming. On the other hand, the emphasis should be placed on profit farming in those localities where farming is practically on a subsistence basis.

PROCEDURE: Outline the approach that is to be made to the problem: procedures to be followed, methods to be used, and availability of needed equipment. Give number, size, and arrangement of plots of fields and number of replications. Give proposed methods for appraisal of results expected -- whether by crop yield, soil loss, increase in soil fertility, weight of animal, time of maturity, etc. If it should be found desirable to alter very much any procedure subsequent to approval of the Work Plan, an amendment, stating the changes and reasons therefor, should be submitted to the Ministry of Agriculture and Animal Husbandry for approval before the changes are made.

TECHNICAL LEADERS: Give name of person who will be in charge of the study, together with names and duties of any assistants.

COOPERATION: If any other agency is to participate in study, name it and the individual, if any, who will assist in the work. State the kind and amount of the contribution to be made by any such agency.

DATE OF INITIATION: Give date or approximate date for starting operation on each project.

ANTICIPATED DURATION: Give length of time study is expected to be continued.

ESTIMATED COSTS: Give as accurate an estimate as possible as to cost the first year and so on, giving separately each major item of expense. An estimate should also be made, if possible, as to the cost of the study during the second year and so on to completion.

APPROVAL:

Submitted: ______________________________ ______________
(Project Leader) (Date)

Recommended: ______________________________ ______________
(Station Superintendent) (Date)

Approved: ______________________________ ______________
(Director of Cooperating Agency if any) (Date)

Approved: ______________________________ ______________
(Appropriate official at Ministry of Agriculture and Animal Husbandry) (Date)

POSSIBLE ORGANIZATION FOR SOIL CONSERVATION SERVICE

Venezuela has come to recognize the existence of serious erosion and land use problems, as well as an acute need for curbing the losses and correcting the evils arising out of inappropriate use of agricultural lands. Solution of these and related problems will not be a simple matter; it will take time, men, and money. The new Ministry of Agriculture is already contributing to the solution of these problems, but it is believed that its services could be greatly strengthened by the establishment of a permanent bureau to carry out a complete soil and water conservation program throughout the country.

Such a bureau could very well follow some such organization as that suggested in Graph A. It probably would not be necessary to complete the organization as indicated in order to get under way a national program of soil and water conservation, but it might be helpful to look ahead to eventual completion of some such an adequately staffed bureau.

In outlining the organization of a Soil Conservation Service for Venezuela, considerable thought has been given the practicability of utilizing facilities

already available in the Ministry. For example, a number of specialists now working under the Ministry could contribute to the formation of a technical staff. A considerable part of the suggested organization probably could be used on the Agricultural Agents now functioning throughout the country. These men, at least some of them, could be instructed in soil conservation practices so that they could combine conservation work advantageously with their present duties.

The several agricultural schools and colleges now operating under the direction of the Ministry should also be taken into consideration in connection with planning a Soil Conservation Service for the nation. Study courses at all of these schools could be extended to include instruction in simple basic soil conservation methods and objectives for the students, especially those training for extension work. All students should be given enough classroom and field instruction to enable them to carry out, with the aid of the department technicians, a rational program of conservation on the land. Such instruction would include lectures, text books, photographs, field observation, etc. The course should be very simple at the start, but it could be extended and elaborated later to include field work, so that the Agricultural Agent, if alert and energetic, would be able to develop plans for and to carry on erosion-control work on the lands within his designated work area.

In operation, the organization might function somewhat as follows: The Agricultural Agents would continue to operate in their designated territory, carrying on as at present with the exception that soil and water conservation work would be added to their duties. This addition would not greatly increase their work load -- it would almost certainly simplify it -- because, after all, good soil conservation to a very large degree is little more than good farming. The territories of some agents, however, might have to be reduced in size.

On the accompanying organization chart the blocks designated as "District A, District B," etc. are geographical areas to which one or more Agricultural Agents are assigned.

It is possible that transportation, the time element, and farm density might eventually make it necessary to set up area supervisors, who would coordinate the work of several Agricultural Agents. These supervisors could act as representatives of the Ministry, transmitting to the field men -- the Agricultural Agents -- all orders and instructions for the conduct of the work. Eventually, as the work load increases, they could have technicians attached to their office who could assist the Agricultural Agents as needed.

Following such possible organization of a Soil Conservation Service as that shown in Graph A, the area supervisors would report to the chief of the Division of Operations, who in turn would report to the Assistant Minister in charge of the Soil Conservation Service. The chief of the Division of Operations would have administrative and technical supervision of the entire field program of conservation and general land use activities. The Assistant Minister in charge of the Soil Conservation Service would report directly to the Minister of Agriculture and Animal Husbandry. He would be a member of the staff of the Minister.

The staff of the Assistant Minister, Soil Conservation Service, probably would eventually comprise the chiefs of four principal divisions.

The Division of Lands would be made up of three sections: Laboratories, Field Surveys, and Cartography.

The Section of Laboratories would operate the necessary laboratories for making analyses and studies of soils. These laboratories would also conduct studies and make soil and water analyses for the other sections of the Service and for the Ministry.

The Section of Surveys would make all physical land inventories needed by the Service and the Ministry. These inventories would serve as the basis for land use planning and field work.

The Section of Cartography would do all drafting work for the Section of Surveys and for the entire Ministry. The Section would also operate a photographic laboratory and do all reproduction work for the Ministry.

The Division of Operations would comprise three sections: Agronomy and Range Management; Forestry and Horticulture; and Engineering, including irrigation and drainage. Each of these would formulate and develop general or over-all plans, methods, and policies. Field work would be carried out through the Division's arrangements for field activities.

These technical sections would pass on qualifications for field technicians, so that the Division of Operations could supply, when necessary, properly trained men to assist the District Supervisors and the Agricultural Agents.

The Division of Land Use would include three sections: Crop Controls, to formulate plans and conduct needed operation for the control of agricultural production through subsidies or otherwise; Land Purchases, to plan and recommend purchases or sales of agricultural lands for relocation of submarginal farmers and other agricultural people, or in the interest of better land use; and Relocation, to plan and carry out operations having to do with movement of families from lands unfit for cultivation to better farming lands, etc.

A Division of Research would include two sections as follows: A section of Erosion Processes and Rates of Losses and a section of Controls of Erosion and Run-off.

In addition to these three sections there could be, if needed, a section of Records and Reports. This section would collect and tabulate useful statistical data on the progress of the conservation work, increased yields as the result of the work, costs, etc.

The suggested groupings of work and personnel and the flow of authority are based on years of experience of the Soil Conservation Service in the United States Department of Agriculture.

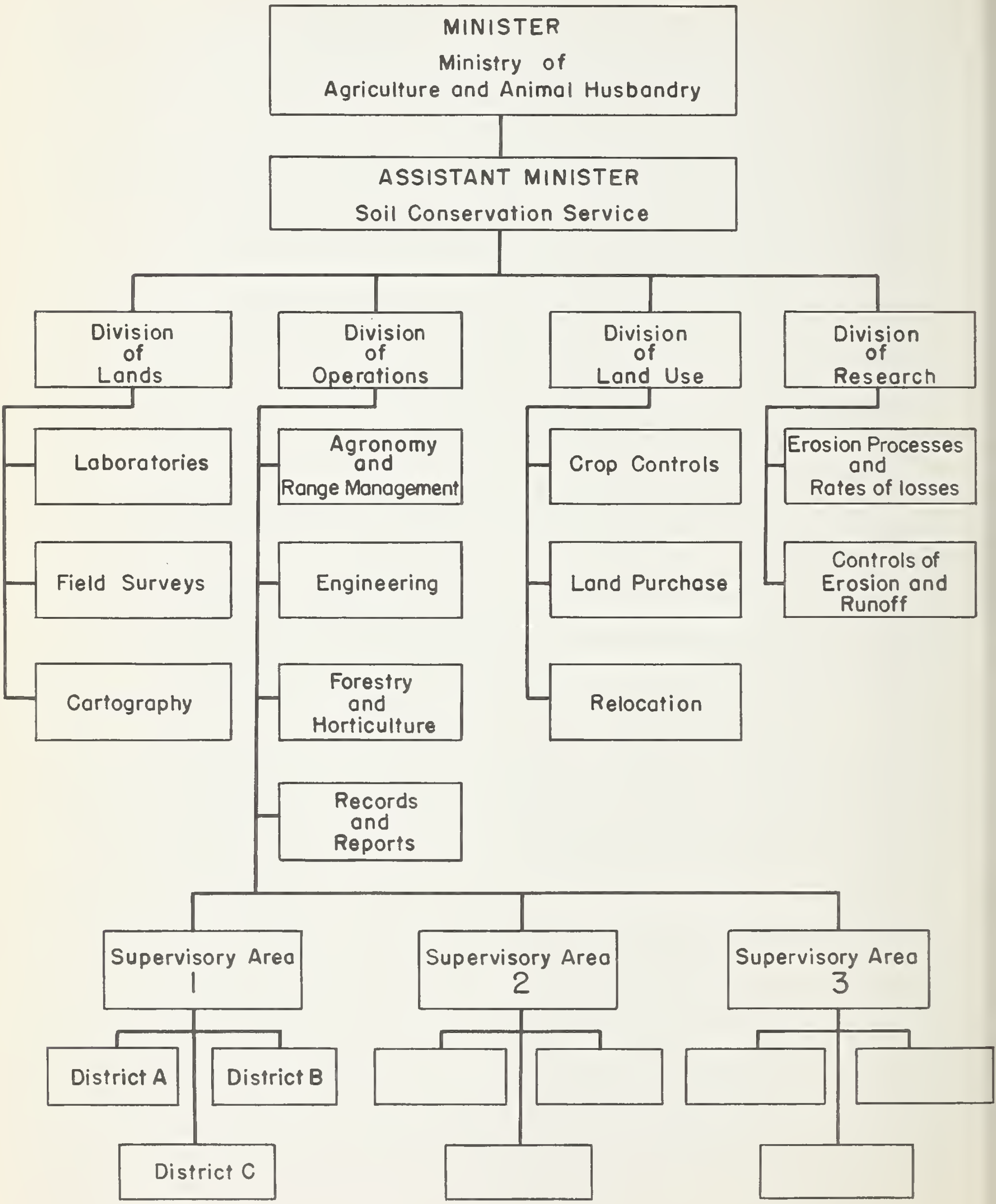
The More Promising Areas for Increased Agricultural Production and Resettlement

Because of unfavorable land conditions obtaining over a large aggregate area now in cultivation and also over much second-growth land (land previously cultivated and abandoned, often recleared and recultivated one or more times; rastrojo), the occupants would be much better off if they could find some way of relocating on better farm land, such as is available in various parts of the country. The unfavorable conditions referred to have been described in the preceeding pages and need no additional treatment here.

It is not meant that all farmers need to relocate on better lands, although many farmers, even those on the more productive lands, need to adopt better farming methods. Some of the more outstanding needs in land use, aside from the need of poor-land farmers to relocate, are: increased use of crop rotations, including the legumes; increased use of animal manure (and appropriate commercial fertilizer when available) and lime; growing of more feed for beef and milk animals; raising more hogs; and carrying on more soil and water conservation work whenever needed. Some of these needs can be met or partly met where farmers are now located, but many other farmers -- perhaps 30 to 40 percent of the total -- are seriously in need of more productive lands than those now available to them. It probably would be advantageous if most of these unfavorably situated farmers could

Graph A

Possible Organization for a Soil Conservation Service
Ministry of Agriculture and Animal Husbandry



be induced to move to better lands, such as might be provided under some appropriate system aided, guided, or directed by the Federal Government, cooperating with the States and possibly also with municipalities and communities.

For soil and water conservation work it might be possible to make some appropriate and adaptable use of a system of soil conservation districts.17/ However, it probably would be advisable first to carry out demonstrations of adaptable soil and water conservation practices in a considerable number of carefully selected problem areas. If later it should be decided that some type of soil conservation districts procedure should be tried out, there would be time for careful consideration of the suggestions and preparation of the necessary instrumentalities and details for setting them up.

Resettlement of poor-land farmers on more productive land would be a matter calling for the most careful consideration of every step in any proposal that might be advanced for this purpose. One of the first considerations, of course, would be the location of favorable lands not now in use. Below are given the locations of some of the more favorable areas found by the Technical Commission. It would be necessary in each case to make detailed studies of the land conditions, including surveys, in order to guide the development of plans, as well as the execution of plans.

Promising Areas for Agricultural Expansion: 1. The nearly level plains about the southern end of Lake Maracaibo, roughly bounded by the Zulia River on the west, the Catatumbo River and the Lake on the north, the mountains on the south, and Chama River on the east.

This locality is characterized by well distributed and ample rainfall. There are extensive uncleared areas of good medium to heavy textured soils (mainly of the Maracay, Uribante, and Encontrados groups). These lands are well suited to the production of such crops as rice, cacao, rubber, sugar cane, corn, bananas, plantains, sweet potatoes, numerous vegetables, and grass. Large acreages of Pará grass are being grown on the cleared areas for pasture. Removal of obstructions from streams and possibly the straightening of some of the channels would minimize or entirely prevent flooding in some cases. It seems possible that some of the higher-lying swamp land could be economically drained and used.

Extending southeastward along the National Railway from kilometer 30 to El Vigia occurs, predominantly, rather droughty sandy land (of the Guacara group). Even this poorer land, under the favorable rainfall conditions, has value for several good grazing and feed grasses, such as gamelote, Guinea, Imperial, elephant, Yaraguá, and molasses.

Dairying is increasing in importance throughout the entire region, and there is ample room for much greater expansion. Tick infestation is very slight and nuches seem to be very nearly absent. The region lacks roads but has the advantage of both rail and water transportation. It is served by El Gran Ferrocarril Tachirense and Ferrocarril Nacional. In addition the Catatumbo and Escalante Rivers are navigable for small lake freighters.

2. Fairly extensive unused areas of the Maracay, Valencia, and Guigue soils are found in a number of places around Lake Valencia. Careful surveys should be made here in order to avoid clearing of such unfavorable lands as those of the Tarbera, Alfareria, and Guacara soil groups.

3. The rolling Alluvial Terraces and associated first bottoms along the Tuy River from the vicinity of Cúa eastward to Panaquire and beyond.

17/ See: "A Standard State Soil Conservation Districts Law," Soil Conservation Service, U. S. Department of Agriculture, 1936.

4. The Rolling Llanos in the vicinity of Valle de la Pascua, Tucupido, Zaraza, and Onoto offer quite promising possibilities for the production of cotton and food crops.

5. The better drained portions of the llanos between San Carlos and Barinas and in the vicinity of Maturín in Monagas offer possibilities for production of food crops and for dairying. The red Barinas and Guataparo soils, the yellow Tamanaco soils and the gray Adolfera are the most promising. They are well-drained and of good physical condition. They are rather low in natural fertility, however, and require good soil management practices, such as the use of lime and animal manures and crop rotations including adaptable legumes.

6. The better drained alluvial soils along many rivers in various parts of the country, such as:

a. the Chururú soils along the Chururú River, in Táchira;
b. the Uribante soils along the Uribante River, in Táchira;
c. the La Miel and Acarigua soils along the Duragua River in the States of Cojedes and Portuguesa;
d. the Maracay soils along the Boconó, in Portuguesa;
e. the Maracay, Valencia, Taborda, and Alpargatón soils along the Yaracuy, Aroa, and Tocuyo Rivers in the States of Yaracuy, Falcón, Carabobo, and Lara; and the rich San Felipe soils occurring on the somewhat higher terraces between San Felipe and Guama;
f. the Toa, Guanoco, and Caripito soils along the Guarapiche and San Juan Rivers in the vicinity of Maturín and Caripito in the State of Monages;
g. the Pampanito, Monay, and Ruston soils along the Motatán River in the State of Zulia, and
h. the Maracay and Acarigua soils along the Portuguesa, Guache, and Acarigua Rivers in Portuguesa.

S O I L S

In the following pages are presented brief descriptions of the principal soil types found in Venezuela (north of the Orinoco). No attempt was made to map the soils, but samples of the principal types were collected for analyses.

SOILS OF THE NORTHERN HIGHLANDS 18/

Residual Soils (well drained)

Non-calcareous group

TOVAR SOILS

The Tovar soils are the dominant and most widely distributed group of the Northern Highlands. Typical virgin profiles may be seen in the few remaining portions of the rich hardwood forest that originally covered the areas occupied by these soils, as in the National Forest at Hotel Rancho Grande, near Maracay. They are developed on mica schist, gneiss, and acid igneous rocks. The soils range from yellow to reddish-yellow in the surface section and from light-red to red in the subsoil. Predominantly, the uneroded soil consists of clay loam or clay; the subsoil is of clay texture, is friable, and has a greasy feel because of the usual abundance of fine mica particles.

These are naturally productive soils but are highly erodible under cultivation. Much land that never should have been cleared has been farmed on steep slopes that favor rapid erosion. Yields have dropped to unfavorable levels in many places and as a consequence much land that once was cultivated as been abandoned to rastrojo.

Rainfall is moderate to high, with alternating wet and dry seasons. Temperatures range from hot at the lower levels to moderately warm at higher elevations (usually the maximum elevation for these soils is not much more than about six or seven thousand feet).

The area in which the Tovar soils predominate is the coastal range of the Northern Highlands extending from the vicinity of Caracas to the Highway connecting Maracay and Ocumare de la Costa.

Tovar Clay Loam

The Tovar clay loam in virgin areas consists of yellow or brownish-yellow, friable, micaceous clay loam about 4 or 5 inches deep, underlain by reddish-yellow, friable, micaceous clay loam or clay. The subsoil proper usually begins at about 15 inches and consists of light-red to red friable, micaceous clay which continues to depths of as much as 8 to 15 feet without a great deal of change except that the mica content is usually higher below depths of about 3 feet. Fragments of partially weathered parent rock are present in the lower subsoil.

At one time or another most of this land has been stripped of its original heavy hardwood forest and put into cultivation regardless of slope. Since there has been practically no attempt to safeguard the soil from erosion, a very large proportion of the land has suffered in varying degrees from erosion -- usually to a degree of grave seriousness. All of the original yellow topsoil is gone from hundreds of thousands of acres and people have become accustomed to speak of these lands as "red lands." This means that at least 15 inches of the upper material has drifted into or part way to the sea. Large areas have suffered even more. In the badly eroded country between Caracas and La Guaira, for example, it is estimated that 25 to 30 inches have been lost and in many of the gullied areas 10 feet or more of soil, subsoil, and partially weathered parent material have been removed by erosion. Locally, the land has been so washed that bedrock is exposed at the surface. Some of these areas -- some of considerable extent, even in sight of the Nation's Capital -- are now difficult to walk over because of the numerous gullies. Even the vegetation has changed. The capacity of the soil to absorb and hold the rains is gone because the soil is gone. The rains run off the skele-

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18/ These soils were correlated by the Committee on Soil Correlation, United States Department of Agriculture headed by Mark Baldwin.

tonized land to swell the floods of streams, and then the streams quickly run dry and the water supply is reduced to a condition of critical scarcity.

Even though nearly all of the Tovar clay loam occurs on slopes of more than 25 percent declivity, most of it has been cultivated at one time or another. Numerous crops are grown and do fairly well where a favorable depth of soil remains. Among the principal crops are: corn, beans, bananas, yuca, potatoes, and coffee. Average yields are low because of erosion and long cultivation without conservation, without replenishment of the humus supply, and without fertilization or crop rotation.

In the higher altitudes considerable coffee is grown. The nature of coffee culture is such that erosion does not take so heavy a toll of the land as it does under cultivation of crops like corn and yuca. The coffee bushes and the shade trees develop a mat of roots and, what is still more important from the standpoint of minimizing erosion, this vegetation lays down a ground cover of plant litter -- leaves and twigs -- that exerts a powerful influence in the direction of soil stability. However, some erosion does take place in coffee plantings, and to a degree of seriousness in places, which could be prevented pretty largely if contour planting and cultivation were practiced.

Although erosion within the coffee plantings is not exceedingly serious as a rule, the coffee plantation system does contribute to the problem as affecting neighboring areas. The labor needs of the coffee fincas is seasonal, and since it has not been considered economically feasible to pay annual wages, the operators find it necessary to offer other inducements to hold their labor supply. A common practice is to allow the privilege of cultivating small conucos conveniently located somewhere in the locality. Cultivation of the excessively steep slopes included in many of these little clearings without regard for erosion has resulted in the impoverishment or ruin of the soil resource over large areas.

Erosion cannot be completely halted on the steeper slopes so long as they are used for the clean-tilled crops, but much could be done toward checking the process. Contour cultivation, planting permanent grass and forest strips at proper places in the fields, and establishment of field terraces are among practices which can be successfully used.

Most of the Tovar clay loam occurs on slopes too steep for continuous cultivation. It is for the most part best suited to some form of permanent vegetative cover, preferably forest.

GUAMITA SOILS

The Guamita soils differ from the Tovar partly in having yellowish instead of reddish subsoils. They are derived from quartz-mica schist, gneiss, and granite. The parent rocks are related to those from which the Tovar soils have been derived, but they usually contain more quartz and less of the clay-forming minerals. Rainfall and temperature conditions under which they are formed are about the same as for the Tovar soil. In fact the two soils in many places are found adjoining each other. They occur throughout the States of Miranda, Aragua, Carabobo, Yaracuy, Trujillo, and the Federal District. Their agricultural value is as good as, perhaps somewhat better, than that of the related Tovar, because of lower susceptibility to erosion. Resistance to erosion is due to the more open, absorptive character of the soil caused by the presence through the profile of more gritty material.

Guamita Gritty Loam

A representative sample collected in a virgin forest near Maracay consists of about 3 inches of loose forest litter and duff, underlain by grayish-brown, highly micaceous gritty loam, with a subsoil, beginning at about 15 to 20 inches, of

yellowish-brown, gritty, highly micaceous fine sandy loam containing numerous gneiss and quartz fragments.

Most of the type is either forested or occupied by rastrojo. Occasional tracts are cultivated to such crops as beans, yuca, corn, and pigeon pea. The yields are low because of failure to check erosion, conserve rainfall, and improve the productivity with manure and rotations containing the legumes.

The Guamita gritty loam occupies steep, erodible slopes, most of which should be restored to permanent cover, preferably forest.

The most characteristic area is in the national forest, north of Maracay.

Guamita Clay Loam (savanna variety)

The savanna variety of Guamita clay loam occurs under grass vegetation and a somewhat lower annual rainfall than the typical soil. The savanna phase is widely distributed through the southerly range of the Northern Highlands, as in the section about midway between Valencia and San Carlos.

A typical profile consists of about 10 to 16 inches of brown clay loam grading into a somewhat lighter brown to yellowish-brown gravelly clay loam, which rests at about 2 feet on decomposed micaceous schist.

Results from a few small cultivated areas have not been very encouraging. Moreover, the soil is highly erodible. Because of this and shallowness of soil and steepness of slope, this kind of land is appraised as being unsuited to agriculture. Its best use probably is for grazing, but good range management practices will be necessary for best results.

BRAMÓN SOILS

Small areas of Bramón soils occur in the eastern part of the Northern Highlands in the State of Monagas. They are described under the treatment of the soils of the Western Highlands.

LA CRUZ SOILS

The La Cruz soils are derived from light-colored sandstone resembling that usually found under the Bramón soils. Rainfall is lighter than that received by the Bramón and the forest is thinner, more on the order of dryforest. The most typical occurrence is about 10 kilometers south of Puerta La Cruz, State of Anzoátegui. Other tracts are found in Falcón, Lara, and Sucre.

La Cruz Sandy Loam

La Cruz sandy loam consists of about 5 inches of reddish-brown sandy loam containing a moderate amount of small black concretions. Below this is compact or hard (dry season) brownish-red clay loam containing a few, small black concretions. From about 20 to 36 inches below the surface olive drab fine sandy clay is encountered.

The forest is rather light and many of the trees are leafless during the dry season. Some erosion is seen here and there as the result of overgrazing.

Probably the most economic use for this kind of land would be for the production of timber products: fuel and fence posts. Forest cover would also be of value for watershed protection.

SARARE SOILS

The Sarare soils include shallow gravelly or shaly soils developed on inter-

bedded quartz schist, mica schist, marmolized limestone, and black shale or slate. These soils are confined entirely to the Savanna Hills and Savanna Mountains of the Northern Highlands, and are the principal soils of these land types. Climatic conditions are about the same as those of the Guamita group of soils.

The soils of the Sarare group are extremely variable within very short distances. Many variations from bare rock to soil 30 inches deep are commonly found within a distance of 200 feet. Those areas having 6 or 8 inches of soil material over bedrock seem to predominate. Rock exposures are not the result of accelerated erosion but of normal or geologic erosion.

A surprisingly good stand of grass is usually present, even where rock exposures are common. The grass takes hold in every little accumulation of disintegrated rock material and every crack and seam in the parent rock. The land is used only for grazing. Under the present type of range management, rather lack of management, the range seems to be deteriorating. The practice of burning promotes rapid runoff, thereby causing loss of water and soil and retarding or preventing the formation of soil, as well as causing damage to lands below. The land is mostly non-arable.

Sarare Gravelly Loam

Sarare gravelly loam in the deepest area found consists of brown, gravelly loam about 6 or 8 inches deep, overlying red clay mottled with yellow and extending to a depth of about 2 feet, where a shallow layer of mixed decomposed rock and clay rests on bedrock.

Native grasses, including coarse unpalatable (when old) kinds, are present in fair to dense stands. Frequent fires may have caused some increase in density of the coarser grasses at the expense of more palatable varieties. However, there are no experimental data found on the subject.

MORROS SOILS

The Morros soils are derived from dark-colored basic igneous rocks under a savanna type of vegetation. They consist of dark-gray soils underlain by yellowish-brown clay, which at about 18 to 50 inches below the ground surface passes into yellow clay containing fragments of the parent rock. Not much soil of this kind was found and that only in the southerly range of the Northern Highlands in the States of Guárico and Miranda -- as on the Experiment Station at San Juan de los Morros.

Rainfall is moderate.

Morros Silty Clay

The Morros silty clay as seen at the Experiment Station at San Juan de los Morros, Guárico, occurs on small rounded hills that rise abruptly about 10 to 30 feet above the surrounding nearly level terrace lands (La Puerta soils).

The surface layer is a dark-gray silty clay about 6 inches deep, containing a small amount of fine gravel and sand. This is underlain by yellowish-brown clay showing a few red mottlings. A freshly crushed fragment of this subsoil material has a distinct reddish color in some instances and yellow in others. At a depth of from about 18 to 54 inches yellow clay is present. This layer contains a considerable amount of partly decomposed bedrock.

None of the type was seen in cultivation. Because of slope and warm climate, land of this kind is best suited to grazing.

<u>Calcareous group</u>

CAPACHO SOILS

Discussed under soils of the Western Highlands.

GUANTA SOILS

The Guanta group includes calcareous soils developed under conditions of low to moderate rainfall and high temperature on limestone and calcareous shales like those which, under more humid conditions, give rise to the Capacho soils. They are among the most extensive soils of the dry portions of Sucre, Anzoátegui, and Falcon. In general they are rather shallow, of brown color, and calcareous in reaction. They are of no value generally except for the production of wood, because of low rainfall and the hazard of erosion.

Guanta Silt Loam

The profile of Guanta silt loam is characterized by a 6- or 8-inch layer of brownish-gray, highly calcareous silt loam containing fragments of calcareous shale and limestone. Beneath this is a brown, highly calcareous silt loam containing about 25 percent of calcareous shale and limestone fragments. This rests on cream-colored caliche about 6 to 10 inches thick. The lower subsoil of caliche shows a content in excess of 64 percent of calcium carbonate.

Much of the type is severely eroded and the general land surface appears whitish in color from the exposed caliche. A great deal of the severe erosion is due to overgrazing by goats. The soil is so erodible that even some of the forested areas have suffered from erosion induced by the grazing.

Because of its present severely eroded condition and its high susceptibility to erosion the type probably could best be utilized for watershed protection. Grazing should be entirely prohibited. Some fuel wood could be harvested from the few more favorable areas.

High Terrace Soils (well drained)

Non-calcareous group

PAMPANITO SOILS

Discussed under Soils of the Western Highlands.

GÜIGUE SOILS

The Güigue soils occur under conditions of moderate to high rainfall, alternating wet and dry seasons, and high mean temperatures. They are not very extensive, having been found only on the high, gently rolling terraces south of Lake Valencia.

Güigue Clay Loam

The surface soil of the principal type of the group -- Güigue clay loam -- is a dark-gray, moderately compact clay loam containing numerous sub-angular fragments of quartz-mica schist. This is underlain at 8 or 10 inches by brown, friable, micaceous clay which extends to a depth of about 30 inches. Below this is a somewhat lighter brown, highly micaceous, friable very fine sandy loam.

None of the type was seen in cultivation, but fields of excellent gamelote grass afford good grazing in the section south of Lake Valencia. It is a very good soil capable of producing a variety of crops, such as corn, cotton, ajonjoli (sesame), peanuts, beans, sorghums, forage grasses, tomatoes, and okra.

SAN FELIPE SOILS

The San Felipe soils occur under conditions of moderate to high rainfall and high mean temperature. They are found along the Yaracuy River in the State of Yaracuy and along the Guaire River in the Caracas Valley. Their most usual location is in the back-bottoms, occurring as strips near the foot of enclosing highlands.

San Felipe Loam

The topsoil of the San Felipe loam, the principal type of the group, consists of a very dark gray or black, micaceous loam about 8 to 12 inches deep. It is rather rich in organic matter and contains enough coarse sand and small gravel to give it a decidedly gritty feel. Beneath this topsoil occurs a yellowish-brown, micaceous gravelly loam, which at about 30 inches is underlain by black gritty, micaceous loam.

The San Felipe loam ranks with the better soils of the Republic. Cotton, peas, pineapples, yuca, and corn have given very good results at the Experiment Station at San Felipe. Corn yields here are reported as high as 58 bushels per acre. The same soils are cultivated in the Caracas Valley with equally good results. Seedling rubber trees (Hevea brasiliensis) at the San Felipe Experiment Station have made marked progress. The type is capable of producing a wide variety of adaptable crops. Those that should be tried out thoroughly, in addition to corn and the usual vegetables and tropical fruits, are potatoes, yamas, tomatoes, okra, acelga, ajonjolí (sesame), peanuts, velvet beans, soy beans, sword beans, and grain sorghums.

The soil is readily susceptible to erosion, but the average gentle slope makes the application of erosion-control practices a relatively simple operation. By terracing, contouring, and strip cropping, erosion can be reduced to a minimum.

LA PUERTA SOILS

The La Puerta soils are red terrace soils developed on old alluvial materials derived largely from basic igneous rocks and in part from limestone. They closely resemble the Wickham soils found along streams of the Appalachian foothills (Piedmont country) in southeastern United States of America.19/

La Puerta Clay Loam

The La Puerta clay loam consists of 8 or 10 inches of dull reddish-brown clay loam, underlain by moderately friable, brick-red clay. At depths of some 24 to 30 inches below the surface of the ground is brick-red clay loam containing around 50 to 60 percent of fine, small, partly disintegrated fragments of basic igneous rock. Gravel consisting of basic igneous rock, intermixed with yellowish clay, is encountered at about 3 feet below the surface.

The type is generally well-drained but the watertable occurs at about 3 feet in the more nearly level and lower-lying areas. This high watertable is a very valuable asset during the dry season but there is a tendency for the soil to become water-logged in the times of high rainfall. These low areas, fortunately, are so situated as to make drainage operations very simple.

Yields of corn are reported as high as 30 bushels per acre. Papayas grown at the San Juan de los Morros Experiment Station are of an excellent flavor. The type is capable of producing a wide variety of crops. With the application of lime, it is believed that alfalfa might be successfully grown.

19/ H. H. Bennett, The Soils and Agriculture of the Southern States, New York: The MacMillan Co., 1921.

ALPARGATÓN SOILS

The Alpargatón soils group includes dark grayish-brown soils developed on rolling to steeply rolling terraces, and under rainforest or near-rainforest conditions of vegetative cover. The mean annual temperature is high. The annual rainfall is about 40 inches, but the dry season is not so pronounced nor is it of such long duration as is common in many parts of the country. They are found along the highway between El Palito and Morón, State of Carabobo.

Alpargatón Clay

The surface soil consists of dark grayish-brown clay about 8 to 10 inches thick. The subsoil to a depth of 30 inches is a brownish-yellow or greenish-yellow, plastic gravelly clay. Below this depth the yellowish clay contains more rounded gravel than in the horizon above.

None of the type was seen in cultivation. Because of the steep slopes and probable high susceptibility to erosion, it is not recommended for cultivation. Forestry seems to be the most promising use for land of this kind. The generally low altitude; the high, well-distributed rainfall; the good drainage and splendid adaptability to trees indicate the possibility of using this kind of land in the production of rubber.

QUIRIQUIRE SOILS

The Quiriquire soils are developed on high rolling terraces under rainforest vegetation. They are of light-grayish color in the surface, and have friable red clay subsoils.

Quiriquire Silt Loam

The Quiriquire silt loam consists of 3 or 4 inches of yellowish-gray silt loam, overlying dull-red, friable clay, which at depths of about 15 inches below the surface is mottled with red. This extends to depths of 6 feet or more. In road cuts the pattern of mottling appears more or less reticulate.

Very little of the type is in cultivation. Small patches are used for bananas and yuca. At the Standard Oil Company School at Caripito a small planting of crotolaria looked very good.

The soil is well suited to a variety of crops adaptable to the climate. The chief limiting factor is the slope on which the type occurs. Much of the area occupied by the Quiriquire clay is too steep for continuous cultivation. Farming should be carried on only with the careful application of effective methods for the control of erosion. From the standpoint of elevation, under-drainage, amount and distribution of rainfall, the Quiriquire silt loam should prove very well suited to the production of rubber, especially if the plantings are placed on the contour.

MOTATAN SOILS

Discussed under Soils of the Western Highlands.

Calcareous group

CHARALLAVE SOILS

The Charallave soils occur on rolling terraces along the Tuy River between Cúa and Panaquire, with soft gray shale material underlying many of the areas. Rainfall ranges from moderate to high (46 inches at Ocumare del Tuy), with alternating wet and dry seasons. The mean temperature is high. They resemble the Palacio soils of the Unare River drainage basin.

Charallave Clay

The Charallave clay consists of about 6 inches of black clay, underlain by reddish-brown compact clay. Beneath this and continuing to a depth of about 3 feet occurs olive drab to yellow clay mottled with gray and containing a few soft lime concretions. This is underlain by greenish-gray sandy clay mottled with rust-brown and containing soft lime concretions, extending to a depth of 60 inches or more. There are local variations in the depth of the black clay surface layer and in the lime content of the lower subsoil.

Not much of the type is in cultivation, during late January (in the dry season) corn and peas were getting along fairly well, except that they were suffering some from drought. Gamelote grass was seen in excellent stands on a relatively large acreage.

Charallave clay is one of the better soils of the country, producing better than average crops whenever the rainfall is favorable. Crops probably should be planted during the rainy season whenever practicable. Most of the cultivated slopes are steep and erosion control practices will have to be used if best results are to be expected.

Low Terrace and Stream Bottom Soils

Non-calcareous group

VEGA BAJA SOILS

The Vega Baja soils have been formed under near-rainforest vegetation. They occur along the Yaracuy River and its tributaries, typically in the vicinity of Urama. Two types were described -- the loam and the fine sandy loam.

All areas of Vega Baja soils observed were under heavy forest cover. The surface of the land is nearly level.

Although not so desirable as the Valencia, La Miel, and Maracay groups, the Vega Baja soils are capable of producing better than average yields of a variety of crops, such as cotton, corn, tomatoes, beans, okra, peas, grasses for forage, potatoes, yamas, and yuca.

Vega Baja Loam

The Vega Baja loam consists of about 3 inches of brown loam of good organic-matter content, underlain by yellow, very friable light loam, which in turn is underlain by mottled blood-red and yellow, moderately plastic clay containing a few subangular quartz gravel. The red part of this layer is rather friable whereas the yellow is plastic. Below about 30 inches the entire mass is more plastic.

The soil is well suited to cotton, corn, grass, forage crops, various vegetables, and probably peanuts.

Vega Baja Fine Sandy Loam

Vega Baja fine sandy loam is a brown, fine sandy loam, high in organic matter, underlain at about 5 inches by yellowish-brown fine sandy loam. The subsoil beginning at a depth of about 10 inches is a yellow fine sandy clay, mottled at about 2 feet with red and yellow. It is a very heavy and plastic clay at this depth.

The crop adaptation is much the same as that of the loam type, but the yields may be somewhat lower with the same treatment.

OCUMARE SOILS

The Ocumare soils are developed on gently sloping terraces around Lake Valencia, as well as along a number of streams. On stream terraces they usually occur near the base of hills and mountains some distance back from the streams. Rainfall under which these soils have been formed is rather high (46 inches at Ocumare del Tuy and 45 inches at Valencia). As over most of the country these rains fall in alternate wet and dry seasons. The mean temperature is high. The natural vegetation is moderately heavy forest.

Because of gentle slope, erosion is of only slight importance. Some small areas have suffered from excessive runoff from adjacent hills and mountains. Reforestation and controlled grazing on these neighboring slopes would improve this condition.

These soils occur at sufficiently high levels to be free from the danger of inundation.

Ocumare Clay

The typical Ocumare clay, as encountered 2 kilometers southwest of Ocumare del Tuy, consists of about 10 inches of black, friable clay, underlain by 3 or 4 inches of yellowish-brown to olive drab sandy clay loam. Below this and extending to a depth of about 30 inches or more is a bluish-black, heavy, plastic clay.

That variety found on the terraces around Lake Valencia is somewhat different from the typical of the Ocumare del Tuy section. Near the Lake, the yellow or olive drab coloring in the upper subsoil is not so pronounced or is locally absent. In places both the surface soil and subsoil are slightly mottled with rust brown.

The Ocumare clay ranks with the better soils of the country. On Colonia Mendoza, near Ocumare del Tuy, in late January -- well into the dry season for that part of the country -- the subsoil was very moist, and peanuts and corn crops looked exceptionally well.

It was reported that peanuts sometimes produced 1,200 kilos per hectare -- about 1,100 pounds per acre Estimated yields for some of the best fields of corn were from 15 to 25 bushels per acre on unfertilized lands. In the Lake Valencia region, corn yields of 15 to 20 bushels per acre and cotton yields of 200 pounds of lint were reported.

The soil is capable of producing many other crops, such as sorghums, beans, vegetables, and various grasses. With irrigation rice should do well.

Ocumare Clay Loam

The Ocumare clay loam was found within the boundaries of the Valencia Irrigation Project. It differs from the clay type principally in the texture of the surface soil.

None of the clay loam was seen in cultivation. At present it is covered with moderately heavy forest or rastrojo.

Crop capability should be about the same as for the clay type.

Ocumare Loam

Ocumare loam is closely associated with the more extensive clay loam type. It differs from the clay loam in texture of the topsoil and in the complete absence of mottling so common to the soil of the clay and clay loam types. Most

of the land is covered with moderately heavy forest. A few small areas are used for gamelote grass and some patches are in rastrojo. It is adapted to the same crops as the clay and clay loam types.

GUACARA SOILS

The Guacara soils are developed on sandy lake and river terraces around Lake Valencia and at the southern end of Lake Maracaibo along the railroad between Santa Barbara de Zulia and El Vigía. Rainfall is high and the temperatures are warm. They are not subject to overflow.

Guacara Sandy Loam

The Guacara sandy loam consists of about 12 to 16 inches of dark grayish-brown, loose sandy loam. The subsoil to a depth of about 3 feet consists of stratified micaceous, loose fine sand of yellow color, mottled with gray. Below this and continuing to a depth of about 50 inches is a loose micaceous, brownish-yellow medium to coarse sand.

This soil because of the loose sandy nature of the subsoil and consequent droughtiness is of little promise for agriculture. In the Valencia area, where it supports a thin stand of trees, weeds, and grasses, it could be used for a limited amount of grazing.

South of Lake Maracaibo, where the dry season is shorter, the Guacara sandy loam may be utilized advantageously for the growing of grasses, such as gamelote, yaragúa, Guinea, and molasses.

Associated areas of Guacara silt loam and loam are of little importance because of small extent. They are more productive than the sandy loam, however, and so are of local importance. They could be used for gamelote, Guinea, imperial, yaraguá, elephant, and molasses grasses and, during the rainy season, for the sorghums, corn, yuca, beans, and possibly potatoes.

MARACAY SOILS

The Maracay soils have the widest distribution of any of the soils found in the country. They are typically developed on the terraces around Lake Valencia. Large tracts occur about the southern end of Lake Maracaibo and other areas of varying size are found along many of the rivers in most of the localities visited. Especially important areas were found along the Yaracuy, Aroa, Catatumbo, Escalante, Caucagua, Tuy, Boconó, Portuguesa, Turbio, Tocuyo, and Guanare Rivers. Local areas are subject to occasional overflow.

The alluvial material of which these soils are composed is derived largely from upland soils formed from mica schist, granite, and gneiss.

Typically, the surface soil is light-brown or grayish-brown and the subsoil yellowish-brown. The lower subsoil characteristically is rather sandy or gravelly. This feature is favorable to the maintenance of good drainage except where such coarse material comes within less than a foot of the surface, under which conditions the soil is likely to be excessively under-drained and droughty. An outstanding characteristic is the presence of enough fine micaceous material to give the moist soil a greasy feel when mashed between the fingers. Drainage, structure, and water retentiveness are especially favorable to agricultural utilization. Along the Yaracuy River and its tributaries the Maracay soils are of darker color (locally almost black) in the surface layer.

In many localities a shallow variety was found where gravel is abundant at depths of around 10 to 18 inches below the surface, as at Guanare in Portuguesa and just east of Maracay in Aragua.

The Maracay soils occur on stream bottoms and lake terraces. They are extensively cultivated and are exceptionally productive.

In crop adaptability the Maracay soils rank with the best in the country. Good crops of sugar cane, potatoes, peanuts, cotton, corn, yuca, ajonjolí (sesame), and irrigated citrus fruits were seen in many parts of the country. Various grasses produce an abundance of forage for livestock. With good soil management yields could be increased easily. Many crops now of little importance could be grown, among which are velvet beans, crotolaria, tomatoes, beans, okra, cabbage, leaf lettuce, acelga, eggplant and possibly soy beans. In localities of high rainfall, as along the Yaracuy and Aroa, Hevea rubber probably could be made a successful plantation and small-farm crop.

Silt loam, sandy loam, silty clay loam, loam, very fine sandy loam, are the important types. Of these, the sandy loams and the silt loam predominate.

Maracay Very Fine Sandy Loam

The Maracay very fine sandy loam is light-brown or grayish-brown, micaceous, very fine sandy loam, underlain at depths ranging from about 10 to 16 inches by yellowish-brown, micaceous very fine sandy loam. At depths of about 24 to 30 inches moderately compact pale-yellow silt loam of a micaceous nature is encountered. Beneath this and continuing to depths of around 36 to 40 inches is usually found grayish loamy sand or fine sand.

The type locality is on the Cotton Experiment Station at Maracay. Here the soil occurs on lake terrace land not subject to overflow. It is well suited to cotton, (ajonjolí) sesame, corn, vegetables, peas, yuca, peanuts, and various other crops. Manure, commercial fertilizers, and rotations including the legumes would increase the yields.

Maracay Silt Loam

The Maracay silt loam consists of about 10 to 20 inches of gray, micaceous silt loam, underlain by yellow fine sandy loam. At depths of about 2 to 3 feet interstratified gray loose sand and loamy fine sand is reached. Generally this very sandy material of the lower subsoil continues to depths of 4 or 5 feet. This typical development of the soil was first found near the banks of the Bonocó River. It is derived from water-lain material of more recent deposition than that from which the Maracay soils of the lake terrace variety along the shores of Lake Valencia are derived.

This is one of the best farming soils of the country. It is easy to cultivate and produces a wide range of crops, such as cotton, corn, ajonjolí (sesame), peanuts, and vegetables.

Maracay Silty Clay Loam

The Maracay silty clay loam to a depth of about 10 to 12 inches consists of a dark brownish-gray micaceous silty clay loam underlain by dull yellowish-brown or olive colored silty clay loam or silty clay to a depth of 28 inches. Below this and continuing to a depth of about 40 inches or more is a gray silty clay loam with a very faint yellowish cast.

The areas examined within the Valencia Irrigation Project are not so well drained as the typical soil, and show some mottling of rust-brown throughout the entire profile.

In crop value it ranks with the lighter-textured sandy loams and silt loams.

Maracay Loam

The Maracay loam consists of grayish-brown, micaceous loam with a yellowish cast, grading at about 6 inches into yellow, micaceous, fine sandy loam which at depths of about 20 to 24 inches is underlain by yellowish-gray gravelly sandy loam.

The type is widely distributed. The area occurring on the highway 21 kilometers west of Taborda in Carabobo, was selected to collect a fully representative sample.

GUANOCO SOILS

The Guanoco soils are dark grayish-brown first bottom soils occurring under heavy forest vegetation. They are of important extent along the San Juan River in the State of Monagas, where the rainfall is heavy and the dry season short. At the Standard Oil Company camp at Caripito good success has been had with oranges. These soils are well suited to a wide variety of crops. They are subject to occasional overflow.

Guanoco Sandy Loam

The Guanoco sandy loam consists of about 6 or 7 inches of dark grayish-brown sandy loam, underlain by gray sandy clay loam mottled with yellow and rust-brown. At depths of 15 inches gray clay mottled with rust-brown and yellow is encountered.

The type is well suited to corn, bananas, peas, beans, and probably cacao and rubber.

CARIPITO SOILS

The Caripito soils are almost black in the surface and gray to pale yellow in the subsoil. They have good drainage and are valuable for the production of corn, yuca, beans, citrus, and vegetables. Bananas do especially well and it is probable that rubber would succeed. They are flooded at rare intervals.

Caripito Sandy Loam

The Caripito sandy loam is a dark-gray to almost black sandy loam, underlain at about 15 inches by dark-gray sandy clay loam with a yellowish cast. Yellowish-gray sandy loam comes in at about 24 to 30 inches and continues without much change to a depth of 40 inches or more.

The type was found along the San Juan River in Monagas. It is a good soil for bananas, corn, vegetables, various fruits and grasses, and probably rubber of the Hevea type.

TAMANACO AND GUATAPARO SOILS

Soils of these groups are found in some of the flat savannas of the Northern Highlands. They are described under the Llanos division, because of their great abundance there.

<u>Calcareous group</u>

VALENCIA SOILS

The Valencia soils are widespread through the highlands of Venezuela. They also occur in the Llanos along the Duragua River, near the point where it emerges from the mountains. The rainfall under which they occur ranges from about 15 inches along the Manzanares River, near Cumaná, to about 46 inches at Valencia.

Typically the Valencia soils are calcareous from the surface down. A variation occurring along the Turbio River, near Yaritagua, does not contain enough lime carbonate in the upper 6 to 10 inches to effervesce with hydrochloric acid. In the terrace area around Lake Valencia snail shells are commonly present throughout the profile. These increase in amount with depth. In many places around Lake Valencia marl beds up to 10 feet or more in thickness underlie the Valencia soils. In most others, as along the Manzanares, Táchira, Turbio, Duragua, Tuy, and Caucagua Rivers, the soil, although generally calcareous, seldom contains recognizable shells. Near Barcelona some areas contain the shells of various marine mollusks.

The typical color of the surface soil is brownish-gray but the color range is from brown to dark gray, even almost black in some areas of the clay type. The clay and silty clay are dark gray to black; in the coarser textured members of the group brownish-gray is the most common color.

A variety with marl occurring at shallow depths -- from about 5 to 15 inches below the surface -- is found in the Lake Valencia area and near Barcelona in Anzoátegui.

These are relatively rich lands, commonly appraised as the best in the country. They have a wide adaptation to crops and are extensively cultivated. The leading crops are sugar cane, corn, and cotton. Fair to good yields are generally reported. Sugar cane is by far the dominant crop. It is estimated that around 70 to 80 percent of the sugar output of the country is grown on the Valencia and Maracay soils. There are some large uncleared areas that could be used very advantageously for the production of food crops for some of the poor-land farmers now cultivating steep mountain slopes. Some of this, however, will need irrigation for year-round cultivation.

The most important types are silty clay loam, loam, and silty clay. None are subject to overflow.

Valencia Silty Clay Loam

The surface soil of the Valencia silty clay loam is a micaceous, highly calcareous, very friable, brownish-gray silty clay loam, containing a few fragments of snail shells and extending to depths of about 2 feet. A remarkable feature is the great thickness of this top layer. Very little change is observable from the surface to depths of 20 or 24 inches. Ordinarily this upper layer is underlain by a thin section -- 2 or 3 inches -- by highly calcareous, yellowish-brown very fine sandy loam of high mica content. Below this and extending to depths of around 3 or 4 feet occurs yellowish-brown, highly calcareous silty clay loam containing much mica and numerous snail shell fragments.

This is one of the most extensive soils of the Lake Valencia plains area. The type area is 16 kilometers southeast of Maracay, about 2 kilometers northwest of the Turmero River.

A shallow variety is underlain at 4 or 5 inches by cream-colored marl which commonly extends to depths of several feet. These marl beds probably could be advantageously utilized for taking out lime to be applied to the acid soils of the Llanos and other parts of the country.

A variety found at Los Cerritos de Caucagua consists of about 12 to 16 inches of brown, very friable, calcareous silty clay loam, underlain at 20 to 24 inches by yellowish-brown very fine sandy loam mottled with gray and rust-brown. This second layer is underlain, in turn, by calcareous, yellowish-brown silty clay loam.

The Valencia silty clay loam is extensively cultivated. Cotton, corn, and sugar cane are the principal crops. The yields are relatively good. Other

adaptable crops are bananas, vegetables, various grasses and peas, and probably rice.

Valencia Silty Clay

Valencia silty clay is a dark-gray, micaceous, calcareous silty clay, somewhat friable when moderately moist. At about a foot below the surface calcareous, micaceous, yellowish-brown silty clay loam is encountered. This also has a favorable friability, allowing easy penetration by water and plant roots. This second layer grades rather quickly into more yellowish material which without other important changes extends to depths of around 40 to 46 inches. Finally, beneath this, yellow, very fine sandy loam of a micaceous, calcareous nature is reached.

The type locality is at the Barquisimeto Experiment Station in the State of Lara.

Sugar cane, corn, bananas, rice, the grasses, peas, mangos, avocados, and other fruits do well. Some of the lower patches would be benefited by drainage, such as can be effected rather readily with open ditches of no great depth.

A shallow variety of almost black silty clay, rich in organic matter, is underlain at about 10 to 15 inches by cream-colored marl usually containing an abundance of mollusk shells. The marl layer is as much as 10 feet thick in places. In other respects this variety is like the typical silty clay type.

Valencia Loam

The Valencia loam to a depth of 10 to 12 inches is a light-brown or grayish-brown loam underlain by yellowish, heavy fine sandy loam, which at depths of about 15 to 24 inches passes into yellowish-brown, micaceous fine sandy loam or loamy fine sand.

The type characteristically is calcareous throughout the profile, but locally the topsoil does not contain enough carbonate of lime to effervesce with hydrochloric acid. The most extensive body of this soil was found just east of Guarenas in Miranda, along the headwaters of the Caucagua River.

BARCELONA SOILS

The Barcelona soils are dark-colored terrace soils occurring near the mouth of the Neverí River. More detailed examinations of the country may reveal other occurrences in other localities. The rainfall is too low in the dry season for doing much more than harvest drops that make their main growth in the rainy season. At the Barcelona Experiment Station excellent results have been obtained with vegetables grown under irrigation, particularly cabbage and tomatoes. Various other crops could normally be grown with irrigation. Content of water-soluble salt is commonly high, so that care must be taken not to select for crop use any but the best drained areas. Crops as sensitive to salt as sugar cane probably should not be grown at all. Rice may prove to be an especially adaptable crop.

The terraces on which they occur are above the overflow line.

Barcelona Silty Clay

The Barcelona silty clay has the remarkable soil depth of around 24 to 26 inches. It consists of dark-gray, friable silty clay. Beneath the top layer there is not much change in texture, but the color becomes slightly yellowish and soft lime concretions appear. Water worn gravel is abundant at depths of about 4 to 10 feet beneath the ground surface.

This is one of the most uniform soils found anywhere in the country. In 26

borings, made in an area of about 4,200 acres, lime was encountered at depths of 24 to 26 inches in 25 of the tests. In the other test lime was reached at 40 inches.

Under irrigation the Barcelona silty clay produces fair to good vegetables, cotton, and corn. Salinity is too high for satisfactory production of such salt-sensitive crops as sugar cane. Rice may be adaptable but in advance of large plantings test plantings should be made in representative places.

CUMANÁ SOILS

The Cumaná soils occur on low marine terraces or flats above the high-tide level. They are highly calcareous and saline, and resemble the Coro soils found in similar situations in the State of Falcón. They have been formed under conditions of low rainfall and high temperatures. At Cumaná, where typically developed the rainfall is 15 inches.

Large areas are completely bare of vegetation and in general the plants are of sparse occurrence. These are cuji, cacti, several grasses and weeds, and a small salt-loving shrub.

The Cumaná soils are of no importance for crops, grazing, or forestry. Attempts have been made to grow sisal but the results are reported as unsatisfactory.

Cumaná Loamy Fine Sand

The Cumaná loamy fine sand is a yellowish-brown, calcareous loamy fine sand about 12 to 14 inches deep, underlain by dark-brown, calcareous silty clay speckled with alkali staining. From about 20 to 40 inches gray, calcareous sandy clay mottled with yellow and rust-brown is encountered.

In many places the dry surface is covered with white salt incrustations. The land is not only valueless for agricultural purposes but presents something of a hazard to adjacent areas by reason of its susceptibility to blowing. Some critically located areas should be planted to salt-tolerant plants for the control of wind erosion.

TABORDA SOILS

The Taborda soils are grayish-brown in the surface section and yellowish in the subsoil. Mica particles are usually abundant. They occupy terrace areas near the sea between El Palito and Morón, and in the virgin condition support good stands of forest.

In value and crop adaptability they rank with the Valencia and Maracay soils. Good bananas, corn, and grasses were growing on these soils at the time they were examined by the Soil Conservation Mission. In some localities they are flooded at times.

Taborda Silty Clay Loam

The surface soil of the Taborda silty clay loam is a grayish-brown silty clay loam, which shows some yellowish color when fragments are crushed. The subsoil, usually beginning at about 5 inches below the surface, is a yellowish-brown, micaceous silty clay loam that fractures under a moderate blow into a small cloddy condition -- that is, when dry. These clods or fragments also show a yellowish color when crushed. From about 12 to 26 inches pale yellow, friable silty clay loam containing considerable fine sand and much mica is encountered. Below this the material consists of pale yellow, micaceous very fine sandy loam of a calcareous nature.

The type is well suited to bananas, corn, and grass. Rice probably can be grown also.

CAMORUCO SOILS

The Camoruco soils occur in shallow depressions which are dry in the season of low rainfall but saturated in times of high rainfall. In their natural imperfectly drained condition these soils are not suitable for either farming or grazing. When drained -- as has been done at the Valencia Experiment Station -- they sometimes produce as much as 25 bushels of corn per acre. Their occurrence as very shallow depression areas on generally well-elevated and well-drained terraces makes artificial drainage a rather simple and very worthwhile matter.

The clay is the dominant type but in some of the depressions the silt loam is found.

Camoruco Clay

The Camoruco clay to a depth of about 20 inches consists of black, plastic clay with a roughly prismatic structure. Below this and extending to a depth of about 30 inches is black clay which shows some olive-drab color when dry fragments are crushed. This subsoil section contains lime in the form of small hard concretions. Micaceous sandy clay of olive-drab color, mottled with rust-brown is found below the second layer. Mica schist rock is usually reached at about 46 inches. Particles of mica give both the soil and subsoil a greasy feel.

When drained, the Camoruco clay produces better than average crops of corn, cotton, and vegetables.

Terrace Soils underlain by claypan or incipient hardpan

TARBERA SOILS

The Tarbera soils, found on stream and lake terraces, consist of mottled gray and rust-brown soils underlain by an almost impervious compact clay having much the same character as a hardpan. Most of the time these soils are very poorly drained or water-logged. They are unsuited to cultivation. Their principal use is for grazing and they are not exceptionally good for that purpose.

They are found on terraces around Lake Valencia and are above the overflow line.

Tarbera Clay

The clay member of the Tarbera group is a gray, moderately friable clay containing a considerable amount of sand and showing mottlings of rust-brown. This surface layer is underlain at about 8 inches by similar material except that the basic color is lighter gray. Beneath this middle section occurs, at depths ranging from about 20 to 30 inches, loose, wet, gray sand (usually coarse) mottled with rust-brown, and finally below this occurs a compact, hardpan-like (or claypan) gray clay containing considerable sand. This compact layer seems to be highly impervious, as the soil is excessively wet most of the time. There is considerable variation in the thickness of the sandy layer overlying the hardpan. It ranges from about 5 to 20 inches in thickness within short distances. The textural composition of the compact layer is also variable, ranging from loamy sand to sandy clay.

The type is of little agricultural value.

Associated areas consist of Tarbera loam. This also is practically valueless, having only moderate usefulness for grazing.

ALFARERIA SOILS

The Alfareria soils, occurring on relatively low lake and stream terraces, consist of grayish-brown soils underlain at about 10 to 24 inches by an impervious sandy clay having the nature of a claypan. They occur on terraces of Lake Valencia near the city of Valencia, none of which are low enough to ever be covered by floodwater.

These soils are practically valueless for cultivation. Probably their best use would be for limited grazing. The natural stand of grass is poor and the tree growth is characterized by very scattered growth of small cují, jobo, and guamacho.

Alfareria Sandy Loam

The principal type of the Alfareria group is a grayish-brown, very friable sandy loam, underlain at depths ranging from about 10 to 24 inches by dark grayish-brown, compact sandy clay of a highly impervious nature. Beneath the second layer stratified beds of alluvial sands, silt, and clay are encountered.

There are some associated patches of loam and clay. Also a number of areas of Alfareria clay loam are associated with the other soils of the group in the vicinity of Valencia. These occur on nearly level flats, in patches as a rule. They are very hard when dry and absorb moisture slowly. This unfavorable soil is very nearly valueless.

MARQUEZ SOILS

A group of soils -- the Marquez -- found on lake terraces near Valencia are characterized by the presence of a compact clay layer in the subsoil. They are not so compact, however, as the Alfareria soils and are yellowish-red in the clay subsoil. Small gravel is also of common occurrence in the subsoil. The surface soils are of dark-gray color and high in mica content. These soils become very dry and hard in the dry season. They are not suited to cultivation but can be used in the production of fuel wood and such grasses as gamelote, Guinea, and molasses.

Only a few small areas were found belonging to the loam and sandy loam types. The loam consists of dark-gray, friable, micaceous loam 4 or 5 inches deep, underlain by yellowish-brown compact loam which is somewhat reddish in the lower part. This is underlain at about 12 inches by very compact, yellowish-red clay containing a considerable amount of coarse sand.

The sandy loam differs from the loam principally in the texture of the surface soil.

SOILS OF THE WESTERN HIGHLANDS

Residual Soils (well drained)

Non-calcareous group

MUCUCHIES SOILS

The Mucuchies soils are derived from light-colored, acid igneous rocks, chiefly granitics. They have developed under high rainfall conditions, alternating wet and dry seasons, and moderate temperatures.

These soils are found at high altitudes, mostly at about 7,000 feet or higher, and almost always on steep slopes -- 25 percent or more. (The type locality is about 3 kilometers north of San Rafael, State of Mérida.)

Much of the land has been or is being cultivated. A large proportion of the wheat produced in the country is grown on the Mucuchies soils. Estimated acreage yields of as much as 16 bushels are produced on the better tended of the gentler, less eroded slopes. Other crops are barley, oats, potatoes (of excellent quality), corn, and a variety of vegetables. Long usage of the land, erosion, scarcity of available livestock manure, and lack of good rotations have led to meager yields -- sometimes not more than 2 or 3 bushels per acre.

Some of the worst erosion conditions in the entire country are found on the steep slopes occupied by the Mucuchies soils. Much of the land has been completely ruined, insofar as further cultivation is concerned. Slopes with gradients as high as 76 percent (actually measured) are planted to wheat. On such slopes, together with deficiency of organic matter in the soil and various handicaps with respect to farming operations, severe erosion is to be expected.

To control erosion effectively, it is estimated that 65 to 75 percent of the land should be retired to some form of permanent vegetative cover, as trees or grass. This, of course, would involve a radical change in farming methods. A change to a more diversified type of agriculture, as fruit and dairy farming, combined with production of small grain and potatoes on the gentler slopes, would have the highly beneficial effect of minimizing soil losses from erosion, plus the added advantages of increased farm income and improved and more nearly adequate diet.

Figure 32. -- Very stony field on moderately sloping Mucuchies soil, valley floor variety. This land produces relatively good crops of white potatoes and wheat.

Mucuchies Gritty Loam

The Mucuchies gritty loam consists of an almost black gritty loam, about 10 to 12 inches deep, underlain by dark-gray sand or loamy sand that quickly passes into a mixture of gray or yellowish-gray sand and granitic gravel, cobbles, and boulders.

The surface is usually stony -- in places too stony for cultivation except by hand methods. From the standpoint of conservation, however, the stony areas of the moderately sloping valley-floor variety are the most desirable for farming purposes (Figure 32), since the presence of the stones is a great aid in holding down soil losses. On soil collected back of stone walls, wheat yields sometimes go up to about 20 bushels an acre (Figure 5 a).

TABAY SOILS

The Tabay soils are derived from thin-bedded gray to yellowish-gray shales. Rainfall conditions under which these soils have developed are similar to those under which the Mucuchies soils have developed: a long season of low to moderate rainfall and a short season of high rainfall. The annual total precipitation is about 70 inches. The mean annual temperature is moderate.

Soils derived from shale in place and on colluvial accumulations have both been included in the group. The Tabay soils are typically developed on the steep slopes just west of Mérida, State of Mérida.

Most of the slopes on which Tabay soils occur are so steep that the land is not suited for the cultivation of anything but perennial crops. Much coffee is grown. The coffee trees (bushes) and over-topping shade trees act much the same as forest in controlling erosion. Bananas seen around Mérida were none too gooa, the altitude (over 6,000 feet) probably being high for this crop. No other important crops were observed on the Tabay. Many formerly cultivated areas, however, are now in rastrojo. These have suffered severely from uncontrolled erosion.

An excellent example of what may be accomplished with adaptable grasses may be seen on the steep mountain slopes to the north of the city of Mérida. A 102 percent slope was entirely covered with a luxuriant growth of molasses grass, and the erosion process was completely stabilized.

Tabay Shaly Silty Clay

Tabay shaly silty clay consists of about 2 to 3 feet of brownish-gray shaly silty clay, usually showing no significant change through the profile. Locally, the subsoil is yellowish-gray at depths of about 14 to 18 inches beneath the surface. Occasional gneiss boulders are present. These were brought down by gravity and slow water movement from higher slopes.

This kind of land is best suited to forest or grass because of its steepness and consequent erodibility. With bench terracing some of the gentler slopes and shoulder positions can be successfully used for potatoes and wheat (Figure 19 a).

INDEPENDENCIA SOILS

The Independencia soils are derived from yellowish-gray, flint-like slates. They have developed under moderate to high rainfall, alternate wet and dry seasons, and moderate to high mean temperatures. Generally they are found at altitudes ranging from about 3,000 to 5,000 feet, occupying mountain slopes in the States of Táchira and Mérida. They were first identified near Independencia, in Táchira.

Where cultivated, the Independencia soils have suffered severely from erosion. They are among the most erodible of all the agricultural lands of the country. Some of the most severely washed sections of the humid mountain country are occupied by the Independencia and Lobatera soils. They should generally be utilized only for pasture purposes and the growing of trees.

Independencia Clay

The Independencia clay consists of a 4-inch surface layer of brownish-gray clay, containing numerous fragments of flint-like rock. Below this layer is a light brownish-gray clay which extends to a depth of about 36 inches. Below this depth yellowish splotches appear throughout the clay material. When dry the surface soil is almost white.

The best use is for pasture, tree crops, or forest.

ALTAMIRA SOILS

The Altamira soils, derived from gray slate, have developed under conditions of moderate to high rainfall, alternate wet and dry seasons, and moderate mean temperature. They occur on steep mountain slopes to the east of the city of Trujillo at elevations ranging from about 5,000 to 8,000 feet, reaching their most typical development at a point about 28 kilometers east of Trujillo on the road to Boconó.

Much of the land has been or is now cultivated. Because of stoniness, erosion has caused only moderate soil losses.

Crops seen on the Altamira soils are wheat and corn, principally. The yields are low. Because of steepness, these soils could best be used under some form of permanent vegetation, as grass for grazing and trees for lumber, fuel. and watershed protection.

Altamira Silty Clay Loam

Altamira silty clay loam consists of dark-gray silty clay loam, of cloddy or faintly prismatic structure. This is underlain at about 15 to 18 inches by some 10 or 12 inches of light-gray silty clay loam with a faint yellowish cast. Below about 30 inches a mixture of light-gray silty clay loam containing at least 50 percent of slate fragments is encountered. The ground surface is about half covered with roughly rectangular fragments of slate, ranging up to about 24 inches long and 4 or 5 inches thick.

Some wheat and corn are grown. Yields are low. Considering the steepness of the land, there has been surprisingly little soil washing.

LOBATERA SOILS

The Lobatera soils are derived from interbedded gray clay shale, yellowish sandy shale, and shaly sandstone. They are developed under high rainfall, alternate wet and dry seasons and moderate to high mean temperature. They occur mostly at elevations of from 2,500 to 5,000 feet. These soils are distributed throughout the San Cristóbal Basin area of the State of Táchira.

Erosion conditions on cultivated and formerly cultivated land range from moderate to excessive. The most severely eroded section of the humid mountain country is found on the Lobatera and Independencia soils. Surprisingly, much of this excessive erosion occurs on relatively gentle slopes. Under good soil management it could have been almost wholly prevented.

Even though highly erodible, the Lobatéra soil is capable, under good soil

management, of producing average or better than average yields of a number of crops. This, however, does not mean that the yields are good; actually, they are rather low. Corn, yuca, beans, pineapples, cabbage, tomatoes, okra, eggplant, and squash are among the crops which may be expected to do well, when given good treatment.

Lobatera Fine Sandy Loam

The Lobatera fine sandy loam, as examined in a typical cultivated field, consists of an 8-inch surface layer of light-brown, heavy fine sandy loam grading into a 10-inch layer of yellowish-brown sandy clay loam mottled with yellow and brown. Below this and continuing to a depth of 36 inches or more is a yellowish-brown, rust-brown, and gray sandy clay, fragments of which when crushed show a yellow color.

The subsoil color within short distances may range from yellow to mottled red and yellow, or even to almost pure red.

The fine sandy loam type is most typically developed about 3 kilometers west of Palmira, State of Táchira. It is fairly well suited to vegetables. Corn, yuca, and pineapple yields could be greatly increased by the use of animal manures, commercial fertilizers, and rotations including the legumes.

Soil conservation should be a regular part of the operations on all farms having much of this kind of soil. Contour cultivation, field terracing, strip cropping, and diversion of runoff are particularly needed practices.

Lobatera Clay

The surface soil of the Lobatera clay to a depth of about 4 inches is a yellowish-brown clay containing a few small ferruginous concretions. This is underlain at from about 4 to 18 inches by yellow clay containing a few ferruginous concretions. From about 18 to 36 inches is a yellow, plastic clay splotched with reddish-yellow and gray, the degree of splotching increasing with depth. Below 36 inches clay shale commonly occurs.

The type locality is near Petróleo, State of Táchira (near the site of the first oil well drilled in Venezuela). Only coffee was seen on this kind of land. It seemed to be producing fairly well. No erosion of any serious importance was noticed.

BRAMÓN SOILS

The Bramón soils are derived from interbedded, white, reddish, and yellowish sandstone. They are developed under moderate to high rainfall, alternate wet and dry seasons, and moderate to high temperatures. They are found at elevations ranging from about 3,000 to 5,000 feet. The Bramón soils are rather widespread throughout the humid mountain regions of the country. Occurring in the States of Táchira, Monagas, Sucre, and Anzoátegui, they reach their most typical development in the vicinity of Hacienda Bramón, State of Táchira.

The principal crops are corn, yuca, bananas, and coffee. Coffee does well and corn fairly well, as yields go on long-used land.

Erosion on lands cultivated to crops other than coffee is moderate to serious. The Bramón soils are apparently not so erodible as those of the Independencia and Lobatera series. In crop adaptability they are about the same as the Lobatera.

Bramón Clay Loam

The surface of the Bramón clay loam to a depth of about 8 inches is a brown,

friable clay loam, which dries to ashy-gray. From about 8 to 20 inches buff-colored, friable clay containing a slight amount of sand is encountered; and from about 20 to 45 inches buff-colored to faintly reddish-yellow clay occurs. This is splotched with yellow, and reddish-brown concretions appear at depths of about 30 inches. Below about 45 inches mottled red, yellow, and gray clay is reached.

Coffee does fairly well on the Bramón clay loam.

LA CRUZ SOILS

This group is described under the treatment of the Soils of the Northern Highlands.

ZUMBADOR SOILS

The Zumbador soils are derived from red sandstones and shales. They are developed under moderate to high rainfall, alternate wet and dry seasons, and moderate temperatures. They occur at elevations ranging from around 3,000 to 9,000 feet. More detailed study would probably result in the recognition of several variations. In areal extent the Zumbador is probably the most extensive soil in the State of Táchira. Small areas are also found in Mérida.

It is most characteristically developed along the Andean Highway just south of El Cobre, in Táchira.

On areas which have been or are being cultivated erosion conditions range from moderate to excessive. On some of the steeper slopes the soil mantle has been completely removed. Corn, beans, wheat, and grasses appear to do fairly well.

The Zumbador soils, while not among the best, are, with good soil management, capable of producing better than average yields from a variety of crops.

Zumbador Silty Clay Loam

The Zumbador silty clay loam to a depth of about 8 to 12 inches consists of dark-red silty clay loam: below this and continuing to a depth of 6 feet or more is a somewhat lighter red silty clay loam. The red color is due to the red color of the parent rock.

On the basis of the usually low yields of the region, fairly good crops of corn, beans, and wheat are produced. Potatoes should do at least fairly well. The soil is very much in need of organic matter, livestock manure, and rotations including adaptable legumes.

PÁRAMO SOILS

The Paramo soils are derived principally from shales. They have been formed under conditions of heavy rainfall, alternate moderate and wet seasons, and cool temperatures. Snow sometimes falls during the rainy season. These soils are found at elevations of above 11,000 feet. They are found in Mérida, Táchira, and Trujillo. The vegetation is of the Alpine type.

None of the Páramo soils is in cultivation; the land is used for grazing to a limited extent. Erosion is only slight to moderate, witn some areas seriously affected.

Páramo Silt Loam

The Páramo silt loam described on the basis of examinations made on Páramo Mucuchies, at an elevation of about 13,500 feet, is a rather shallow soil. It consists of about 8 inches of brown silt loam containing a moderate amount of

shale fragments. Below this is a brown, very shaly silt loam to almost pure shale. The only agricultural use is for grazing, and this is only fair.

Calcareous group

CAPACHO SOILS

The Capacho soils are derived from limestone and calcareous shales. They are developed under climatic conditions of moderate to high rainfall, alternate wet and dry seasons, and moderate to high temperature.

Where typically developed, about 6 kilometers west of Palmira in Táchira, the Capacho soils consist of very dark gray to black calcareous soils, with calcareous subsoils usually somewhat yellowish in color. The elevation in the type locality ranges from about 3,500 to 5,000 feet.

There are some included small areas of brown soils derived from calcareous shales, such as those seen along the highway between Trujillo and Boconó in the State of Trujillo. It is probable that detailed surveys and additional studies would reveal the necessity for recognizing some important differentiations in the areas that have been grouped together as Capacho in the general description of land conditions.

The Capacho soils appear to be rather widely distributed through the humid parts of the country -- in Táchira, Trujillo, Monagas, Anzoátegui, and Falcón, but they may not be very extensive in any given locality.

Of all the soils found in the northern highlands, the Capacho is the least erodible. On relatively gentle slopes of the same gradient and under the same type of cultivation the Lobatera and Independencia soils have suffered severe losses from erosion as compared with the Capacho, losses from which have been only moderate. This does not mean, however, that conservation practices are not needed on the Capacho. Even though soil loss is slow, it goes on during every rainfall. Some areas have been severely damaged even on moderate slopes.

On the steeper cultivated slopes along the Trujillo-Boconó highway disastrous washing has resulted from cultivating up and downhill.

The Capacho soils are probably the most productive upland soils of the country Their closest rivals are the alluvial Valencia, La Miel, and Maracay. Relatively good crops of corn, yuca, pigeon pea, and a variety of vegetables are commonly produced. Very large and sweet pineapples are grown on the Capacho clay near Capacho, in Táchira. Estimated yields of corn on the eroded areas of the Trujillo-Boconó development, however, run around 3 or 4 bushels per acre, and of wheat around 5 bushels per acre. On the steeper, higher-lying areas the leading crop is coffee.

Capacho Clay

The Capacho clay in its type locality consists of about 16 inches of black, heavy clay, usually calcareous, plastic when wet and crumbly when dry. During dry weather the surface tends to pulverize to a fluffy condition. Deep cracks commonly form on drying. Between depths of about 16 and 28 inches black calcareous clay mottled with yellowish-brown is encountered. Below this is the parent limestone. Depth to the bedrock varies from about 18 to 36 inches. The shallower areas are those on the steeper slopes and in the more severely eroded spots.

A large proportion of this land is cultivated and the yields are better than average.

Capacho Stony Clay

The Capacho stony clay, as first encountered in a coffee plantation about 12 kilometers east of Trujillo, consists of an inch of leaf litter, over dark brown to black, calcareous clay which extends to depths of about 20 to 24 inches without very much change. The soil is rich in humus and is not very erodible because of the abundance of stones, some of which are 3 feet in diameter or more.

Most of that seen is used for coffee.

High Mountain Terrace Soils

BAILADORES SOILS

The Bailadores soils are dark gray to black and occur on terraces in the high mountain valleys. The rainfall is high with alternate moderate and wet seasons and a moderate mean temperature.

They are developed from materials derived by water-transportation from the Mucuchies soils, occur under about the same altitude and climate, and their crop adaptability is the same. The Bailadores soils, however, occur on much gentler slopes, are less erodible, and may be much more safely planted to clean-tilled crops.

Because of their gentle slopes, the Bailadores soils have not suffered much from erosion. Being one of the better soils of the high mountain area, every effort should be made to protect them from the consequences of erosion.

At present the leading crops are wheat, oats, and barley (in limited amounts), corn, vegetables, and potatoes.

Bailadores Gritty Loam

The surface of the Bailadores gritty loam is a black gritty loam about 12 inches thick. From about 12 to 26 inches the material consists of brownish-yellow micaceous gritty loam somewhat heavier than the topsoil. Below 26 inches and continuing to a depth of 36 inches is a dark-gray, micaceous clay loam which becomes gritty again in the lower part.

This soil is most typically developed on the high terrace east of La Grita, at an elevation of about 300 feet less than Páramo Zumbador.

Bailadores Sandy Clay Loam

The Bailadores sandy clay loam consists of a 5-inch surface layer of very dark gray to almost black, highly micaceous, friable sandy clay loam. Below this and extending to a depth of 24 inches or more is a yellowish-brown, micaceous clay loam.

The type locality is at the Wheat Experiment Station near Mucuchies.

High Mountain Terrace Soils (underlain by hardpan)

MÉRIDA SOILS

The grayish-brown to brown Mérida soils occur on terraces in high mountain valleys. They are developed under conditions of alternating light and high rainfall seasons, and moderate temperatures. They occur at elevations ranging from about 5,000 to 11,000 feet.

Because of their limited extent, the Mérida soils are of no great agricultural

importance except along the upper reaches of the Chama River. They are rated as fair to good for agricultural purposes.

Where hardpan is present it seems to be more or less permeable, or at least to have no very adverse effect on crops. In many places hardpan is absent. The soils have good drainage.

In crop adaptability the Mérida soils are similar to the Bailadores and Mucuchies. On the average, however, lower yields may be expected, particularly of those crops that have deep root systems.

Mérida Clay

The type locality of the Mérida clay is on the high mountain terrace about the city of Mérida. Typically, the soil consists of an 8- or 9-inch surface layer of grayish-brown clay containing about 5 to 10 percent of gritty granitic and quartzose material. Below this top layer and continuing to a depth of about 2 feet yellowish-brown clay loam is encountered. This becomes more yellowish and gritty in the lower part. Hardpan of splotched yellow, red, and black color, ferruginous and gravelly, underlies many areas at about 2 feet below the surface of the ground. This is usually 6 inches or more thick. The type is adapted to corn, potatoes, vegetables, and grasses.

Mérida Clay Loam

The Mérida clay loam occurs at elevations of about 10,000 feet. It is more brownish in color than the clay type and hardpan is reached nearer the surface. A typical profile, as that at the Mucuchies Wheat Experiment Station, shows the following characteristics: brown, micaceous clay loam to a depth of about 5 inches; yellowish-brown clay loam or friable clay, underlain at depths of about 12 inches by a hardpan composed of mica schist and quartz gravel cemented with ferruginous material. The hardpan usually is about 6 inches thick.

The soil will produce good yields of wheat if properly handled. Potatoes and various vegetables should succeed also. Conservation measures would go far toward building up yields, especially if leguminous crops were included in the rotations.

High Terrace Soils (well drained)

PAMPANITO SOILS

The Pampanito group includes red terrace soils occurring along streams and on old peneplains at elevations of about 2,000 feet or less. They are developed under conditions of moderate to high rainfall, alternating wet and dry seasons, and high temperatures. They are found in many parts of the country -- in the States of Trujillo, Zulia, Aragua, Carabobo, Miranda, Monagas, and the Federal District. The type locality is on the terraces around Pampanito, Trujillo.

Very little of the type was seen in cultivation. Some good citrus fruits and cowpeas were observed at the Pampanito Experiment Station.

The texture, slope and general character of the Pampanito soils are favorable. By building up the organic content of the soil with rotations including legumes and with applications of animal manure relatively good returns should be expected with citrus fruits, figs, tomatoes, okra, beans, cowpeas, corn, and probably cotton and potatoes.

Pampanito Silty Clay

This soil, to a depth of about 10 or 12 inches, is a reddish-brown silty clay, which becomes increasingly red with depth. From 12 to about 34 inches

brownish-red silty clay, slightly mottled with yellow in the lower part, is encountered. Water-worn gravel is usually present below about 3 feet.

This subsoil is adapted to citrus fruits, tomatoes, okra, beans, corn, and probably cotton and potatoes.

MOTATÁN SOILS

The Motatán soils occur on old gravelly terraces, the topography of which is rolling to hilly as the result of geologic erosion. Many of the hillocks and ridges are flat-topped, but the slopes are moderately steep to very steep. Rainfall is moderate and falls in alternating seasons of relatively high and low precipitation.

Although most typically developed on the terraces between Valera and Motatán, these old gravelly terrace soils are found in many parts of the Republic -- in Trujillo, Zulia, Cojedes, Carabobo, Miranda, Guárico, Anzoátegui, and Monagas.

Although a few areas were seen growing poor to fair corn, the Motatán soils are not recommended for cultivation, because of their excessively high susceptibility to erosion, and gravelly, droughty character. They are of some value for grazing, and would be of greater value under good range management.

Their best use generally is for forest for the production of fuel, fence posts, etc., and for the protection of watersheds.

Motatán Gravelly Sandy Loam

The undisturbed Motatán gravelly sandy loam consists of about 10 inches of brownish-gray gravelly sandy loam overlying yellowish-brown gravelly sandy loam, which at about 15 to 18 inches below the surface passes into yellowish-red gravelly sandy clay loam carrying around 50 percent of gravel, cobbles, and sand.

The best use is for forestry.

Motatán Sandy Clay Loam, Eroded Variety

This variety of the Motatán sandy clay loam owes its distinguishing characteristic to the removal of the topsoil by erosion, along with much or most of the subsoil from the normal gravelly sandy loam type. In many areas the land has been ruined by gullying. So severe has been the washing under of this condition that only the stony-gravelly-sandy parent material is left.

This type in its present condition is not only useless but is an actual menace to better lands downstream (Figure 33). Every effort should be made to halt the constantly increasing rate of erosion of these critical areas. Reforestation, prohibition of grazing, and prevention of burning are practices which should be put into effect at the earliest possible time.

MONERO SOILS

The Monero soils occur on terraces of the Uribante River, about 50 to 100 feet above the lower alluvial plain, near the point where the river emerges from the mountains. Here the valley widens out as the stream enters the region of the Llanos.

Climatic conditions are characterized by high rainfall and warm temperatures.

The soils are very sandy, of light-gray color, and underlain by deep accumulations of water-lain sand, gravel, and cobbles. Productivity is low; the best use is for grazing or forestry.

Figure 33. -- Trans-Andean highway damaged by deposition of erosion debris about 10 kilometers Northeast of Timotes, Mérida.

Monero Fine Sandy Loam

The topsoil of the Monero fine sandy loam is about 6 inches deep, of gray color and fine sandy loam texture. Below this is buff-colored loamy fine sand which extends to depths of about 30 inches. Buff-colored loamy fine sand with 50 to 60 percent of water-rounded gravel, cobbles, and boulders of granitic and sandstone material extends from the 30-inch level to depths of 8 feet or more.

The soil is of low natural productivity. Grasses seem to do fairly well, especially molasses grass. Probably grazing is the best use.

TORONDOY SOILS

The Torondoy soils are found on high terraces of water-lain and colluvial materials. They are representatively found in the San Cristóbal Basin section of western Venezuela, along such streams as the Torbes, Lobaterita, and Quinimari Rivers.

The surface is gently rolling, slopes seldom exceeding 12 percent except along escarpments separating the benches from lower alluvial plains. On the sloping areas cultivated land has suffered considerably from the effects of uncontrolled erosion. These are relatively good farm lands, nevertheless. Long usage, however, has reduced their fertility considerably. Very little has been done to balance the impoverishing effects of continuous cropping and practically nothing to check soil washing. The soils are in great need of animal manure, crop rotations that include frequent growths of legumes, and contour cultivation, along

with other soil and water conservation measures. Rainfall and temperature conditions are favorable for the production of many crops. Among the crops seen are beans, okra, tomatoes, corn, cotton, tobacco, eggplant, squash, papaya, citrus fruits, figs, sorghums, and various grasses. Two outstandingly promising legumes for inclusion in soil-improving rotations are gallinazo and velvet beans.

Torondoy Sandy Clay Loam

The surface soil is a grayish-brown sandy clay loam about 8 to 12 inches deep. The subsoil to a depth of about 24 to 30 inches is a light yellowish-brown sandy clay loam with occasional rust brown mottlings. Below this section is a yellowish-brown clay or heavy clay loam showing a few red mottlings or splotches. A mixture of gravel, sandstone boulders, and clay usually is reached at about 3 feet. Occasional large boulders are also scattered over the surface and in places are found in the soil profile. The type is characteristic of the terraces in the immediate vicinity of the city of San Cristóbal.

It is adapted to corn, various vegetables, grasses, sorghums, etc. Yields under ordinary treatment are rather light. With good crop rotations, including leguminous crops and application of manure, production can be increased appreciably.

Torondoy Sandy Loam

The surface soil of the Torondoy sandy loam is a light-brown, micaceous, sandy loam about 3 inches deep. Below this occurs yellowish-brown, micaceous sandy clay loam mottled with red and yellow. Below depths of about 30 to 40 inches and extending to about 60 inches is a gray, highly micaceous sandy clay loam, mottled with red, yellow, and rust brown colors. Still lower in the profile the material becomes much lighter in color -- almost white in places -- and there is less mottling. Occasional boulders occur in the subsoil.

The sandy loam type is common on the high terraces bordering the Quinimari River. The area considered most typical is that where the Quebrada Torondoy enters the Quinimari.

Torondoy Silty Clay Loam

The topsoil of the Torondoy silty clay loam is a slightly reddish-brown silty clay loam mottled with yellow. This is underlain at about 5 inches by yellow, friable silty clay with a faint reddish cast. Between depths of about 18 and 40 inches below the surface is a friable clay mottled gray, red, and reddish-yellow and containing considerable partly decomposed sandstone gravel. Below about 40 inches and extending to some 6 or 7 feet is a purplish-red clay splotched with light gray and yellow. Partly decomposed sandstone, gravel, and cobbles are present in this lower section also.

The silty clay loam type is most extensively developed on the terraces of the Lobaterita River. The most representative profile is of the kind found on the terrace just above Estación Táchira.

The agricultural value of the type is about the same as that of Torondoy sandy clay loam. It is somewhat better suited to grass.

Low Terrace and Stream Bottom Soils

<u>Non-calcareous group</u>

ESTACIÓN SOILS

The Estación soils occur in first bottoms along the smaller streams of the

San Cristóbal Basin country. Both rainfall and temperature are favorable. They are found in typical development along the Carapo River and its tributaries, as most typically in the vicinity of Rubio, Táchira. These soils are used largely for the growing of sugar cane, but they are well suited to various other crops adapted to the climate.

They are sometimes flooded for short periods, after flash rains.

Estación Fine Sandy Loam

The Estación fine sandy loam consists of about 8 inches of brown heavy fine sandy loam underlain by yellow, friable fine sandy clay loam. Locally, the subsoil is mottled with gray. Sugar cane, corn, and various vegetables are grown on the type.

EL COBRE SOILS

The El Cobre soils occur on the first bottoms and on low terraces of mountain streams receiving drainage water from areas of the red Zumbador soils. These are reddish-brown to chocolate-brown in color, of favorable mechanical structure, well drained between overflows, and retentive of moisture. Gravel and cobbles are of common occurrence. The lower bottomlands are subject to occasional overflow.

Fair crops of corn, beans, and potatoes were seen on the type. With good soil management yields of all these crops could be substantially increased. Among other crops that should prove successful are cabbage, tomatoes, okra, soy beans, gallinazo, velvet beans, and squash. Rainfall conditions are favorable to agriculture.

El Cobre Silty Clay Loam

The El Cobre silty clay loam consists of reddish-brown to chocolate-brown silty clay loam underlain at about 18 to 24 inches by loose water-rounded sand, gravel, and cobbles. In places the color ranges to purplish red, resembling the Bermudian[20] soils of the stream bottoms in the Triassic sandstone and shale areas of southeastern Pennsylvania and others of the East Central States of the United States of North America.

These are good potato, corn, and vegetable soils. They need manure and rotations with legumes for the production of good yields.

TÁCHIRA SOILS

The Táchira soils were found in the first bottoms and on low terraces of the Táchira River. The climate is semiarid, with rather high temperatures.

In their natural condition these soils are best suited to grazing. Under irrigation, corn does very well. There is every reason to believe that with irrigation various crops could be successfully grown, especially where manure is used and the legumes are included in the crop rotations.

Runoff from adjacent eroded slopes has caused severe damage in many places, and some large gullies are actively cutting at the present time. This condition can be remedied best by protecting the eroding slopes in the neighboring hills and mountains.

These soils are not subject to overflow from rising river waters.

20/ H. H. Bennett, The Soils and Agriculture of the Southern States, New York: The MacMillan Co., 1921.

TÁCHIRA CLAY

The Táchira clay to a depth of about 24 to 30 inches is a faintly reddish brown clay containing a slight amount of small quartz gravel. Apparently there is more organic matter in the surface 8 or 10 inches than in the material beneath. The subsoil to depths of around 60 inches or more is of about the same color and physical character, but is slightly mottled with light yellow and light red.

Rainfall is low. With irrigation, corn, the sorghums, melons, vegetables, and various grasses can be successfully produced. Application of organic manures or commercial fertilizers, together with rotations including such legumes as gallinazo and velvet beans, will increase the yields.

CHURURÚ SOILS

The Chururú soils occur on low terraces and first bottoms along the Chururú River and also along the Guárico River in the Llanos. The rainfall is moderate to heavy, most of which falls in the 6-months rainy season -- May to October.

They are flooded at times during the rainy season.

Molasses grass and gamelote grass of excellent quality were seen growing along the Chururú River.

None was seen in cultivation but the soil ranks with the better soils of the country. Corn, bananas, sweet potatoes, papayas, sugar cane, yuca, peanuts, potatoes, and vegetables should do well.

Chururu Silty Clay Loam

The Chururú silty clay loam consists of about 2 inches of brown, friable, slightly micaceous silty clay loam, underlain by yellow, friable, slightly micaceous silty clay loam which extends to a depth of about 20 inches. From 20 inches to about 35 to 40 inches is a yellow, friable silty clay loam mottled with gray. Rounded gravel occurs at depths of from 38 to 42 inches.

Calcareous group

VALENCIA SOILS

The Valencia soils are described in some detail under the discussion of the Northern Highlands. In the Western Highlands they are confined to the drier localities and can be utilized for crop production with satisfactory results only where irrigated. But without irrigation grasses do well enough for good grazing purposes.

SOILS OF THE LLANOS

Some of these Llano types occur in the savanna areas within or surrounded by mountains of the Highlands and also in the Maracaibo Basin. (Some of the smaller savannas are locally called calcetas.)

Rainfall in the Llanos is generally high. Available data show a range from 39 inches at Ciudad Bolívar to 52 inches at San Fernando de Apure. The country is characterized by distinct wet and dry seasons and high temperatures. During the wet season rain water stands on large areas of the typical flat grassland country -- the predominant type of Llano land -- much or all the time, but in the dry season the same areas become dry and hard and water is generally exceedingly scarce except in the principal streams. Some of the lower-lying grasslands remain moist throughout the year. Areas near the foot of the high gravel escarpments as along the outer bottoms of the Uribante River near Santo Domingo, Táchira, are

permanently water soaked as the result of seepage or springwater from the deep gravel strata. At one place in this locality a fair-sized area of permanently saturated peaty muck soil was found.

Residual Soils (well drained)

Non-calcareous group

GUÁRICO SOILS

The Guárico soils are derived from gray sandstone similar to that which gives rise to the Bramón soils of the mountain country. They occur in gently rolling areas near the mountains in the States of Cojedes and Guárico. The surface soils are yellow and the subsoils light yellow in the upper part and mottled gray and red in the lower part. They become hard and dry in the dry season and are not particularly desirable for cultivation.

Guárico Fine Sandy Loam

The Guárico fine sandy loam consists of 6 inches of yellow or slightly brownish-yellow fine sandy loam, underlain at about 20 inches by light-yellow silty clay loam, which at about 30 inches below the surface passes into gray, plastic clay mottled with rust-brown, yellow, and red. The red color usually increases with depth. The soil is inclined to harden in the dry season, especially under a cover of grass. It is an acid soil of rather low natural productivity and is not recommended for extensive cultivation except where yields have proved favorable under preliminary trials on small fields. If commercial fertilizer or manure were available, probably fairly good crops of cotton, peanuts, and yuca could be produced. Plowed areas planted to such feed crops as Guatemala grass, Uba cane, molasses grass, and pigeon pea possibly could be successfully used for beef cattle. Cowpeas and velvet beans probably could be grown in rotation with other crops in a way that would improve the producing value and at the same time furnish considerable protein feed. Citrus fruits may prove successful, especially with irrigation. At present very little of this soil is cultivated. Applications of a ton or more of ground limestone per acre and use of livestock manure probably would increase the productivity. Such treatment with lime likely would not need to be repeated for several years. Tests to determine the best methods for use of lime are needed for this and the other acid soils of the country.

TUCUPIDO SOILS

The Tucupido soils, derived from soft gray clay shales, are associated with and related to the Loma and Palacio soils of the rolling Llanos in the watershed of the Unare River. They are characteristically red in the surface and have gray subsoils containing a few small black concretions and a fairly large amount of small gypsum crystals. These soils occur on lower slopes and adjacent flats where crops are subject to excessive flooding by runoff water. They are not especially valuable for agricultural purposes.

Tucupido Clay

The Tucupido clay is a heavy, compact red clay containing a few black concretions. There is not much change in the general appearance of the material to a depth of around 20 inches but below this level, tough gray clay mottled with red and yellow and containing a few small black concretions and a rather high percentage of small gypsum crystals, is encountered. The surface, even under natural forest conditions, cracks to a depth of about 24 inches during the latter part of the dry season.

Except for a few small plantings of gamelote and Guinea grass, none of the Tucupido clay was seen in cultivation. The stands of these grasses were only fair.

Because of their occurrence in situations subject to flooding by runoff water and because of the severe cracking, land of this kind is not adapted to cultivation. The best use is for the production of trees.

Calcareous group

LOMA SOILS

The Loma soils are also derived from soft gray shales, but they differ from the Tucupido in that they have limy subsoils. Typically, they are reddish-brown or red, except in the lower subsoil which is brownish-yellow or gray mottled with yellowish-brown. These are relatively good lands for cultivation, producing fairly good yields of corn and cotton.

Loma Silty Clay

The Loma silty clay is a reddish-brown silty clay, underlain at about 6 inches by heavy red clay containing a few small black concretions. This red clay layer grades below into brownish-yellow clay mottled with rust brown and containing occasional small black concretions. At about 2 feet gray clay occurs, mottled with yellowish-brown and containing lime in the form of small specks and hard concretions.

This is one of the better soils of the Llanos. Estimated acre yields on unfertilized fields are: cotton, 150 pounds of lint; corn, 25 bushels. With good soil management these yields could be materially increased, perhaps doubled in the case of cotton. Livestock manure and rotations including the legumes would be very beneficial. Other crops of some promise are grass, hay, grain sorghums, beans, tomatoes, okra, cabbage, and onions.

Erosion has been rather serious in some fields -- chiefly sheet erosion. No examples of very serious gullying were observed. Because of the rolling surface it will be necessary to take due precaution to protect cultivated fields from washing. Unless checked, the washing will continue at a constantly accelerating rate until the lands are ruined for farming.

PALACIO SOILS

The Palacio soils, like the Loma and Tucupido with which they are associated, are derived from soft gray shales. They are calcareous near the surface, usually at depths not exceeding 6 to 14 inches. The color of the surface soil ranges from dark gray with a yellowish cast to yellowish-gray. In the subsoil the color is uniformly yellowish-gray. Clay texture predominates in all the horizons. These are the best soils to be seen over wide areas of the Llanos. They are well suited to cotton and corn.

Palacio Clay

The Palacio clay consists of 6 to 14 inches of dark-gray to yellowish-gray clay, containing a few small black concretions and water-rounded quartz gravel. The subsoil is a yellowish-gray clay containing numerous small black concretions and hard lime concretions.

From the standpoint of actual and potential productivity, the Palacio clay, with the possible exceptions of the low terrace La Miel, Valencia, and Maracay soils, is the best soil in the uplands of the Llanos. A large part of the cotton and corn produced in the States of Anzoátegui and Guárico is grown on this type. Under the system of growing cotton without manure, commercial fertilizer, or soil-improving rotations, the yields reported are good.

Cracking does considerable damage to crops, allowing rapid desiccation of the soil and probably also damage to the root system. With cultivated crops the hazards of surface cracking could be minimized by the use of organic mulch (as crop residues). More frequent cultivation might also prove beneficial, especially to destroy weeds without plowing them under, as can be done with shallow-going, subsurface plows. 21/

Crop adaptability is about the same as that of the Loma silty clay, but the yields are better. Some sloping fields have been damaged by erosion. Contour cultivation, strip cropping, and terracing would largely control the erosion and at the same time save much of the rainfall by holding it in the fields to be stored for subsequent crop use.

Crop rotations including the legumes would be especially helpful, both from the standpoint of erosion control and conservation of rainfall. Lime is probably not needed on this type, but it is on the more leached Loma silty clay.

Soils Derived from Old Water-lain Materials (well drained)

CANOA SOILS

The Canoa soils are red in color, very sandy, and of low productivity. They are associated with the yellow San Tomé and the almost white Cachipo soils. All three of these groups are distributed through the eastern part of the Llanos.

Canoa Loamy Sand

The Canoa loamy sand consists of about 2 inches of brownish-red loamy sand, underlain by brick-red, moderately compact loamy sand containing considerable fine quartz gravel and a few small black concretions. This subsoil frequently extends to depths of 5 to 8 feet without any apparent change of much importance.

This is among the poorest of the Llano soils. Its excessively sandy texture, acidity, low water-holding capacity, low fertility, and potentially high susceptibility to wind erosion are enough in the way of natural deficiencies for appraising it as non-agricultural. However, with good range management, including the practices of rotational and deferred grazing and adjustment of livestock numbers to carrying capacity, it might be practicable to use the land for animal-husbandry purposes.

Water erosion thus far has been of rather negligible importance except on limited areas of steep land. The generally flat surface will prevent very serious soil washing.

SAN TOMÉ SOILS

The soils of the San Tomé group are yellow and very sandy throughout the profile. They occur in association with the red Canoa and the almost white Cachipo soils. Low in content of organic matter and plant nutrients and acid in reaction, the productivity is discouragingly meager.

San Tomé Sand

The surface soil of the San Tomé sand to a depth of about 2 inches is yellowish-gray, loose sand. This is underlain by compact, yellow sand which continues without important change to a depth of 4 feet or more.

21/ Using Crop Residues for Soil Defense. Miscellaneous Publication, U. S. Dept. of Agriculture, No. 494.

In the matter of agricultural value and present and potential erosion conditions, there is little or no difference between the San Tomé and the Canoa.

CACHIPO SOILS

The Cachipo soils are almost white and very sandy. They occupy the more nearly level and slightly lower parts of the Llanos, in association with the higher lying red Canoa and yellow San Tomé soils. Their agricultural value is very low.

Cachipo Loamy Sand

The Cachipo loamy sand to a depth of about 10 inches consists of loose loamy sand which is grayish-brown when moist and almost white when dry. The subsoil is a loose, very light-grayish loamy sand with occasional faintly yellowish mottlings which increase with depth. Below about 30 inches is found almost white sand mottled with yellow. The third layer extends to depths of 44 inches or more.

From the standpoint of agricultural value, this is one of the poorest soils in the country. It is of acid reaction and is low in content of organic matter and plant nutrients.

BLANTON SOILS

The Blanton group includes very sandy soils of brownish-gray color in the surface and gray color in the subsoil. They occur both as forested land and grassland. Although rather widely distributed, they are usually found in relatively small patches. The principal type -- loamy sand -- is very poor. The group is typically and most extensively found east of Zaraza in the State of Guárico.

Blanton Loamy Sand

Blanton loamy sand is a loose, brownish-gray loamy sand overlying, at 6 to 8 inches, loose, gray loamy sand which extends to a depth of 36 inches or more. It is an acid soil, low in plant nutrients, and has no special value for cultivation and not much for grazing. Its most economic use would be for restricted grazing in the grassed areas and for the production of fuel in the forested areas.

NORFOLK SOILS

The Norfolk[22] soils are gray sandy soils with yellow subsoils. No very large areas were seen, but the distribution is rather wide in many parts of the eastern Llanos.

Norfolk Loamy Fine Sand

The surface soil of the Norfolk loamy fine sand is a gray, loamy fine sand; this is underlain at 6 or 7 inches by yellow loamy sand containing a few small black concretions. And this, in turn, is underlain by white sand at about 40 inches below the surface of the ground.

None of the type was observed in cultivation. It is too infertile for that purpose, being very low in content of plant food and having an acid reaction. Land of this kind is suitable only for grazing, and it is rather poor for that purpose. In southeastern United States land quite similar to this is successfully used for vegetables where heavy applications of "complete" commercial fertilizers are made.

22/ H. H. Bennett, The Soils and Agriculture of the Southern States, New York: The MacMillan Co., 1921.

GUANIPA SOILS

The Guanipa soils are reddish sandy soils with compact light-red to red subsoils occurring on the Llano mesas. They have no value except for grazing.

Guanipa Sand

The Guanipa sand to a depth of about 3 inches consists of gray sand, somewhat yellowish in the lower part. In undisturbed condition the surface appearance is almost white. It is underlain by reddish-yellow, somewhat compact sand, which, in turn, overlies yellowish-red, compact loamy sand that extends to depths of 5 feet or more. The type resembles the Ruston soils somewhat, but is more compact in the lower subsoil.

The type is useful only for grazing. It should be handled very carefully, with the best range management practices put into effect. Some burned areas have suffered from blowing.

BARINAS SOILS

The Barinas soils are red, lateritic, acid soils encountered over most of the nearly level or dominant type of Llano country. The surface to a depth of about 5 inches is grayish-brown and usually light-textured. The subsoil is yellowish-red heavy fine sandy loam which becomes brick-red in the lower part. At depths of about 40 inches brick-red sandy clay comes in.

These soils resemble the Ruston, but are more red in the lower subsoil.

Barinas Fine Sandy Loam

The grayish-brown heavy fine sandy loam of the surface soil of the Barinas fine sandy loam is underlain at about 5 inches by yellowish-red heavy fine sandy loam, which continues to a depth of about 30 inches. This second layer is underlain by a brick-red sandy loam to a depth of 40 inches and this, in turn, is underlain by a brick-red sandy clay extending to depths of 70 inches or more.

For general crop purposes the Barinas soils are rated as of only fair value. They are best suited to such grasses as gamelote, Guinea, molasses, elephant, and Guatemala. Best results are had by planting after breaking out the native sod, composed largely of grasses that become coarse and tough early in the dry season. With livestock manure or commercial fertilizer and rotations including the legumes this soil should produce fairly good peanuts, cotton, sweet potatoes, and various vegetables. Lime would improve the soil for the production of legumes.

Since very little of the Barinas soils are in cultivation, present erosion is only slight. Danger from erosion will never be great except in the steep terrace escarpments and not even here if good vegetative cover is maintained.

TAMANACO SOILS

The Tamanaco soils are wide spread through the Llanos, occurring on much of the gently sloping grasslands.

Around San Carlos, Cojedes, where this kind of soil is most extensive, the surface soil consists of 4 or 5 inches of grayish-brown sandy loam to silty clay loam. The subsoil is of yellow color and silty clay texture. Small black and reddish concretions are usually present below about 2 feet.

As encountered on the Sabana Monay in Trujillo and in the State of Yaracuy, the surface soil is more nearly brown in color and the subsoil somewhat lighter in texture.

A number of types were found, as the silty clay loam, sandy loam, and very fine sandy loam.

Tamanaco Silty Clay Loam

The surface soil of the Tamanaco silty clay loam consists of about 4 inches of grayish-brown silty clay loam. This grades into a brownish-yellow silty clay loam which extends to a depth of about 9 or 10 inches, where yellow silty clay loam containing numerous black concretions comes in. At about 2 feet this third layer passes into yellow silty clay mottled with red and containing many black and red concretions. This fourth layer continues to a depth of 4 feet or more.

From the standpoints of mechanical composition, topography, and drainage, the Tamanaco silty clay is one of the better soils of the Llanos. However, it is low in natural fertility and will require good soil management for the production of average to good yields, especially applications of livestock manure or commercial fertilizer, and rotations including legumes. Because of high acidity, treatment with lime -- at least a ton of crushed limestone per acre -- would increase the chances for success with some of the soil-improving legumes.

The crops most likely to succeed are cotton, velvet beans, pigeon pea, sword beans, tomatoes, onions, citrus fruits, yamas, and sweet potatoes. Guatemala grass, molasses grass, Uba cane for forage, and possibly some of the drought-resistant grain sorghums.

Tamanaco Clay Loam

The Tamanaco clay consists of a grayish-brown clay loam about 6 inches deep, underlain by yellow friable clay which grades at about 18 to 20 inches into yellow, friable fine sandy clay mottled with red and containing a few rust-brown concretions. Patches of clay are associated with this type. The crops mentioned under the silty clay loam are probably equally well suited to the clay loam.

Tamanaco Fine Sandy Loam

The fine sandy loam type was established 27 kilometers west of San Felipe, State of Yaracuy, along the highway to Barquisimeto.

The Tamanaco fine sandy loam consists of about 4 inches of grayish-brown heavy fine sandy loam, underlain by grayish-brown heavy sandy clay loam with a yellowish cast. Friable fine sandy clay loam, which resembles the yellow color of cottonseed meal, is encountered at depths of about 2 feet. Sandy loam and very fine sandy loam occur here and there. Their agricultural value is probably the same as that of the fine sandy loam.

With good soil management, including crop rotations that carry a frequent leguminous crop, and application of lime and livestock manure or commercial fertilizer, this soil should produce better than average yields of various crops. The most promising crops are cotton, corn, yuca, beans, crotalaria, velvet beans, peanuts, Guatemala grass, molasses grass, pigeon pea, and probably some of the grain sorghums. Citrus fruits would probably succeed with irrigation and application of manure. Peanuts and sweet potatoes should succeed with the aid of manure or commercial fertilizer.

RUSTON SOILS

The Ruston soils occur in various parts of the savanna lands of the country. They are found in the Llanos, the Maracaibo Basin, and on the savanna-like flats of the Highlands.

The surface soils are gray or brownish-gray in color and usually coarse tex-

tured -- chiefly sandy loam. The subsoil, beginning at about 8 to 10 inches, is a reddish-yellow to yellowish-red friable sandy clay, containing a few mica flakes. At depths of 30 to 40 inches below the surface the subsoil often becomes more sandy, frequently changing to heavy fine sandy loam, and the color is commonly much like that of cottonseed meal.

Ruston Fine Sandy Loam

The Ruston fine sandy loam is a grayish-brown fine sandy loam about 8 inches deep. This is underlain by friable fine sandy clay of reddish-yellow to yellowish-red color. Below about 40 inches reddish-yellow, fine sandy loam is encountered.

The virgin soil is heavily clothed with savanna grasses. A few trees, as chaparro, are commonly scattered in areas like those where this type was first encountered: 4 kilometers west of Tocuyito, Carabobo.

Not much of the Ruston fine sandy loam is in cultivation. The surface of much of this type is essentially flat, so that there is little danger of erosion. In a few places on slopes of only 3 to 4 percent sheet erosion has removed at least 25 percent of the surface soil. The soil is of low fertility naturally, containing very little organic matter and plant nutrients and having an acid reaction. For good yields, it will need livestock manure or commercial fertilizer, as is true on the soil over extensive areas in the coastal plains of southeastern United States of North America. The legumes, particularly the velvet bean, should succeed. It would be a good soil-building crop for this kind of land.

Among the most promising crops are peanuts, yamas, sweet potatoes, citrus, yuca, cotton, velvet beans, pigeon pea, Guatemala grass, molasses grass, Uba cane for forage, and possibly some of the drought-resistant sorghums. Livestock manure or commercial fertilizer would increase the yields. A ton of crushed limestone per acre would be beneficial especially in connection with growing legumes.

Ruston Loamy Fine Sand

The topsoil of the Ruston loamy fine sand is a loose, gray loamy fine sand of acid reaction. This is underlain at around 12 to 16 inches by slightly compact, reddish-brown to dull-red loamy fine sand which continues without much change to about 3 feet. Below this and continuing to about 40 inches or more is a brownish-red or dull-red compact fine sandy loam.

The Ruston loamy fine sands are poor and of little value for agriculture. They can best be utilized in their present forested state for the production of fuel and timber.

GUATAPARO SOILS

The Guataparo soils are among the most widely distributed and extensive soils of the Llanos. They also occur on the nearly level savanna lands associated with the mountain areas. They have developed under moderate to high rainfall -- about 35 to 50 inches annually, and occur on both timbered and grass-covered lands, without much apparent difference in the soil profiles of the two conditions. The timbered variety, however, has the reputation of being the more productive.

The surface soil is typically grayish-brown, though it varies locally to light brown or even reddish-brown. The subsoil color is characteristically red, but it sometimes changes to yellowish-red in the lower part or even to yellow -- as in the thinly forested country near Ortiz, Guárico. The good mechanical composition and the favorable topography, together with the good drainage are desirable characteristics from the standpoint of agricultural use. Unfortunately, low natural fertility and a highly acid condition are serious handicaps. According

to local information fairly good yields are obtained the first year or two on the virgin soil. Then yields decline. Liming, manuring, use of commercial fertilizer, and growing legumes in crop rotations would probably go far toward improvement of the productivity of the Guataparo soils. Commercial fertilizers should improve yields generally.

The most promising crops are peanuts, pigeon pea, velvet beans, sword beans, cotton, corn, okra, tomatoes, Uba cane and the sorghums for forage, and Guatemala, elephant, Guinea, gamelote, imperial, yaragua, and molasses grasses. On the heavier soils rice can be produced, especially with manure, fertilizer, or crops of legumes.

Guataparo Sandy Clay Loam

The Guataparo sandy clay loam consists of about 6 inches of grayish-brown to light brown fine sandy clay loam, overlying friable red fine sandy clay which frequently extends to depths of 6 feet or more. The lower subsoil -- below about 36 inches -- is more friable, somewhat micaceous, and lighter red in color, and contains a few small black concretions. At the San Carlos Experiment Station excellent results have been obtained with Guatemala grass and Uba cane for stock feed. With good management, including the use of manure or fertilizer and the growing of legumes in rotation the various crops mentioned above should succeed.

Some associated areas consist of Guataparo sandy loam.

Guataparo Silty Clay Loam

The silty clay loam type of the Guataparo group is a grayish-brown silty clay loam, underlain at about 5 inches by dull brick-red silty clay. This commonly extends to 3 feet below the surface. The color often changes to a cottonseed-meal yellow and the texture to friable silty clay loam.

A variety of the type, as examined in a formerly cultivated field on Hacienda San Luis, near Valencia, consists of 3 inches of faintly reddish-brown sandy clay loam overlying yellowish-red sandy clay loam, which at about 1 foot below the surface passes into yellowish-red, friable light sandy clay loam to heavy sandy loam containing many small ferruginous concretions or accretions. This is underlain, at about 3 feet, by splotched yellowish-red and ocherous yellow very friable sandy clay loam containing soft concretions or accretions of a ferruginous nature.

In a small timbered area a few hundred feet from the type locality of the silty clay loam -- 4 kilometers south of San Carlos on the Camino Libertador -- the soil is the same except for the color of the lower subsoil. Here in this forested area the color below 3 feet is yellowish-red rather than yellow.

Guataparo silty clay loam is probably the best of the red Llano soils. But there is generally a decided drop in the yields following the first year or two of cultivation. Illustrating this point in yields of rice reported by a farmer operating near San Carlos, in the State of Cojedes, were 3,000, 2,000, 1,500 kilos per hectare for three consecutive years following the first cultivation.

With good soil management practices, crops which may be expected to succeed with manure or fertilizer, and with rotations including the legumes, are yuca, corn, cotton, okra, tomatoes, rice, pigeon pea, and various grasses such as Uba cane, Guatemala, gamelote, Guinea, yaraguá, and molasses.

Guataparo Fine Sandy Loam

As examined just west of the Guataparo River along the road from Valencia to the Carabobo monument, the Guataparo fine sandy loam consists of 3 inches of

reddish-brown, friable fine sandy loam, underlain at about 1 foot by brownish-red fine sandy clay loam which quickly grades into brick-red, friable fine sandy clay loam. This continues to a depth of about 30 inches, where blood-red lateritic clay containing occasional small water-rounded quartz gravel, is encountered. At the Valencia Experiment Station, the surface is more of a grayish-brown and small flakes of mica are present in the subsoil.

Under good farm management, including the use of manure or commercial fertilizer and lime, Guataparo fine sandy loam should produce average or better yields of peanuts, sweet potatoes, corn, cotton, yuca, beans, and a variety of vegetables. In its present unimproved state it is best adapted to the growing of sorghums and grasses such as elephant, Uba cane, Guatemala, molasses, Guinea, and gamelote for livestock feed.

ADOLFERA SOILS

The Adolfera group of soils are found in the rather limited heavily forested areas of the western part of the Llanos. The largest single area seen lies to the southwest of San Carlos in Cojedes.

The surface soils to a depth of 10 or 12 inches are dark brownish-gray in color, friable, highly micaceous, and usually of heavy texture -- silty clay loam or clay. The subsoil is yellowish-gray silty clay, which extends to a depth of about 20 inches, where yellow silty clay containing a few reddish-brown concretions comes in.

Adolfera Silty Clay Loam

The surface soil of the Adolfera silty clay loam consists of about 10 inches of dark brownish-gray, friable, micaceous silty clay loam. This grades first into yellowish-gray silty clay mottled with yellow, and, second, at about 18 inches, into yellow silty clay mottled with red and containing a few reddish-brown ferruginous concretions or accretions.

The Adolfera silty clay loam is among the best of the Llano soils. It will produce average to good crops with less fertilizer and other soil improvements. It is probably one of the best rice soils in the entire Llano area, particularly if irrigated. Livestock manure or commercial fertilizer and rotations with legumes alternating with the non-leguminous crops would increase the yields.

Soils Derived from Old Water-lain Materials (poorly drained)

PLUMMER SOILS

The Plummer soils are widely distributed over the Llanos but are most common in the States of Monagas and Anzoátegui. The surface soil is gray or light-gray loamy sand, which becomes somewhat lighter colored below. At about 2 feet compact gray sandy loam is encountered. At depths of around 4 or 5 feet mottled yellow and red impervious clay is encountered. The soil is very wet during the rainy season, but dries out to a hard condition with cessation of the rains. The land has no value for cultivation.

Plummer Loamy Sand

The Plummer loamy sand consists of 8 or 9 inches of gray loamy sand which grades at about 15 inches into light-gray loamy sand. Below this is encountered compact, gray sandy loam mottled with yellow and rust-brown. Gray sandy clay mottled with rust-brown, yellow, and red appears at depths of 50 or 60 inches. The soil is very wet during the rainy season and hard in the season of low rainfall.

The Plummer loamy sand is a poor, very acid soil suitable only for grazing.

PAYA SOILS

The Paya soils occur on the lower-lying flats of the Llanos, where they usually are flooded one or two months during the high rainfall season. Vegetation is mostly grass and scattered palms. In places, however, the palms are plentiful enough for the areas to be known as palm forest. The surface soils are brownish-yellow mottled with gray and rust-brown, and the subsoil red, mottled with gray. The gray color gradually increases with depth until about 6 feet the color is gray with occasional red mottling. A few black concretions or accretions are usually present below the brownish-yellow surface layer. These are acid soils of low productivity.

Paya Silty Clay

The Paya silty clay consists of about 5 to 7 inches of brownish-yellow silty clay mottled with gray and rust-brown, underlain by stiff red clay mottled with gray and containing a few small black concretions or accretions. Between depths of about 4 to 6 feet tough gray clay mottled with red is reached.

None of this soil was seen in cultivation. It has the character of land favorable for the production of rice under irrigation.

The type is found in the section just east of Palenque, in Guárico, and between El Chaparro and Cachipo, in Anzoátegui.

OBISPOS SOILS

The Obispos soils occupy flat shallow depressions in the Llanos. The surface soil ranges from about 10 to 16 or 18 inches deep. It is of ashy-gray color when dry but has a somewhat brownish appearance when wet. The principal types encountered are the very fine sandy loam, sandy loam, and silty clay. Beneath the upper section commonly occurs an incipient hardpan or at least a layer containing a relatively large amount of concretionary material. Generally this layer is 4 to 6 inches in thickness; locally only a few "buckshot" concretions or accretions are present. This second layer rests on a stiff, impervious, bluish-gray clay at depths of about 18 to 28 inches, and, in turn this passes quickly into yellow-plastic clay, mottled with reddish-yellow. At about 50 to 60 inches below the surface of the ground bluish-gray clay, mixed with gravel and sand comes in.

Obispos Very Fine Sandy Loam

Obispos very fine sandy loam is an ashy-gray very fine sandy loam which appears somewhat brownish when wet, underlain at about 1 foot by a thin layer of incipient hardpan of ashy-gray very fine sandy loam containing numerous brown "buckshot" concretions or accretions. This layer is usually only about 3 or 4 inches thick and rests on bluish-gray, stiff, impervious clay specked with reddish-yellow. At about 20 inches yellow plastic clay specked with reddish-yellow comes in and extends to depths of about 50 inches, where it is underlain by wet bluish-gray clay mixed with gravel and sand.

Both surface and underdrainage are poor. Water stands on the land for considerable periods during the rainy season. It is very acid in reaction and low in content of available plant nutrients. The land is said to have generally failed to produce any crop planted on it. Grass grows naturally, however, and grazing is the use to which it is best suited.

There are associated areas of Obispos sandy loam, having essentially the same characterizing features of topography, drainage, profile distinctions, and agricultural value.

Also, there are occasional areas of Obispos silty clay, which differs from the very fine sandy loam chiefly in texture of the surface soil. In this the incipient hardpan layer is not present so generally and is seldom thicker than about 2 inches. It, too, has no apparent use beyond fair grazing value.

Hardpan Soils

PALENQUE SOILS

The Palenque group of soils is widely distributed over most of the Llanos. Much of the undulating to rolling country between El Sombrero and Palenque, in Guárico, as well as in the Llano Mesas, is occupied by these hardpan soils. Many small patches are present, also, in the sandy sections north of Ciudad Bolívar. In all places the hardpan is of ferruginous character, but varies with the type and locality. Between El Sombrero and Palenque in Guárico it nearly always contains considerable water-worn quartz gravel, up to 25 percent in some localities. This variety is very hard and rather porous. In the sandy types north of Ciudad Bolívar the hardpan contains no gravel. Here it is very hard also, resembling iron oxide. This variety is not solidly cemented, however, but is fragmentary and has the appearance of having been shattered.

These are poor, acid soils, valuable chiefly for grazing.

On the Llano Mesas the clay content is high and the hardpan is well cemented and almost completely impervious. This variety of hardpan has the appearance of being composed of concentric spheres of all sizes cemented together with a blood-red, ferruginous sandy clay material.

Palenque Sand

The Palenque sand so typical of many sandy areas of the Llanos consists of about 3 inches of light-gray sand, which overlies reddish-yellow, compact sand. The second layer at about 45 inches below the surface rests on purple, red, and black, very hard, ferruginous hardpan, commonly fractured. In road-cut exposures the hardpan has a wavy upper surface and occurs at depths ranging from about 1 to 4 feet. In thickness it varies from about 6 to 24 inches.

The type is of no value except for grazing, and even this value can be developed only when good range-management practices are employed, such as rotational and deferred grazing and construction of stock-watering ponds or tanks.

Considerable erosion has taken place on this type and in many places hardpan is exposed. Careful control of grazing is the only practical way for preventing land damage by erosion.

Palenque Loamy Sand

The loamy sand of the Palenque group was seen only in the Llano Mesas section. On the Mesa Guanipa near San Tomé the type consists of about 4 inches of gray loamy sand, underlain by reddish-yellow, very compact sandy loam containing about 5 to 10 percent of fine quartz gravel and a few small black concretions or accretions. At depths of about 28 inches red, sandy clay with much concretionary material is encountered. This overlies blood-red sandy clay hardpan at depths of 30 to 36 inches below the ground surface.

On the escarpments (farallones) of the Mesas the hardpan varies from a few inches to 8 or 10 feet in thickness.

The vegetation on the Palenque loamy sand is grass, with very few trees. Of the most nearly treeless areas found in the country the largest tracts are to be seen in these areas.

Grazing appears to be the only practical value for these poor lands. The low fertility, low water-holding capacity, and high susceptibility to wind erosion are sufficient reasons for appraising the type as non-arable.

Some associated areas of Palenque gravelly sandy loam occur here and there. They are of practically the same low value as the loamy sand.

Low Terrace and Stream Bottom Soils (well drained)

Non-calcareous group

TIRGUA SOILS

The Tirgua soils are found on low terraces and in stream bottoms along the larger waterways in the western part of the Llanos. They are often flooded during the rainy season.

The surface soils are of dark grayish-brown color, and the subsoil yellowish-brown with a faint reddish cast in the upper part and yellow in the lower part. They are underlain by water-rounded gravel at depths ranging from about 30 to 60 inches. Their agricultural value is good.

Tirgua Silt Loam

The Tirgua silt loam consists of dark grayish-brown silt loam, underlain at 5 or 6 inches by yellowish-brown, friable clay loam having a faint reddish cast. This becomes more yellowish on the lower part and rests on gravel and sand at about 30 inches. Small flakes of mica are commonly disseminated through the soil and subsoil.

The Tirgua silt loam, one of the best soils of the Llanos, is adapted to a variety of crops. It produces very good bananas, yuca, corn, and sugar cane. Other crops, such as yamas, sweet potatoes, cotton, plantains, velvet beans, sword beans, pigeon pea, tomatoes, okra, ajonjolí, onions, and melons are reported as adaptable crops.

URIBANTE SOILS

The Uribante soils occur on low terraces and bottoms along the larger streams of the Llanos and the Maracaibo Basin. They are red to reddish-brown in color and are formed of alluvial materials derived from areas occupied by the red Zumbador soils of the highlands.

Two types were recognized: the fine sandy loam occurring along the Uribante River, in Táchira, and the silty clay along the La Grita, Orope, and Guarumito Rivers, in the Maracaibo Basin.

They are well drained but are occasionally flooded during the high rainfall season and as judged by the prolific growth of gamelote grass are of excellent productivity.

Uribante Fine Sandy Loam

The Uribante fine sandy loam consists of a dark brick-red fine sandy loam resting on water-worn gravel at depths of about 38 to 40 inches.

Large areas have been seeded to gamelote grasses, with excellent results. The water table is sufficiently high to prevent crops from suffering during the dry season, and a gravelly substratum provides adequate under-drainage.

The Uribante fine sandy loam should produce good crops of bananas, plantains,

melons, tomatoes, ajonjolí, peanuts, beans, corn, and various other crops adaptable to the climate. A large variety of grasses should do well. Moriche palms seem to do especially well, fruiting heavily.

Uribante Silty Clay

The Uribante silty clay consists of a 4-inch layer of reddish-brown silty clay overlying light brownish-red silty clay having a faint yellowish cast in the lower part. In places, largely due to obstructions, such as log jams, the type is subject to overflow.

The only crops seen growing on this type were bananas and plantains. Removal of obstructions from the stream channels would prevent most of the flooding and open large areas of this soil for cultivation.

The Uribante silty clay is an excellent soil, capable of producing a wide variety of crops, notably rice, sugar cane, potatoes, yamas, corn, cotton, and many forage producing grasses.

ACARIGUA SOILS

The Acarigua soils are very dark gray to black, micaceous, and generally heavy-textured soils found on low river terraces in the western part of the Llanos. No data are available as to whether they are flooded during the rainy season, but from appearances they are not.

Acarigua Clay

The Acarigua clay is a very dark gray to black silty clay having a greasy feel due to an abundance of finely divided mica. At about 10 inches beneath the surface is a yellowish-gray silty clay which grades quickly into yellowish-brown silty clay, extending to depths of 40 inches or more.

The Acarigua clay is a good agricultural soil. Its proximity to good supplies of fresh water makes it even more valuable because of the possibility of irrigation. Its chief drawback is a tendency to become hard and crack deeply in times of drought. Under irrigation of course this would not be a problem. Applications of lime would probably prove beneficial as would manure or commercial fertilizer.

With good soil management there is every reason to believe that the Acarigua clay would give relatively good yields of a number of climatically adaptable crops, such as corn, cotton, bananas, yuca, tomatoes, okra, and beans.

TOA SOILS

The Toa soils occur along the larger streams in the State of Monagas and along the Apón and Cogollo Rivers in the Maracaibo Basin. They are not subject to overflow.

The surface soil textures are chiefly silt loam and sandy loams. These are gray soils in the surface portion, and olive drab in the subsurface. The subsoil, usually encountered at about 10 to 16 inches, is a compact gray clay that shows an olive-drab color when fragments are crushed. These are good lands for farming purposes.

Toa Silt Loam

The Toa silt loam has a surface soil of about 8 inches that consists of gray silt loam. This is underlain by olive drab fine sandy loam. The subsoil, beginning at about 10 to 16 inches beneath the ground surface, is a compact, gray clay that shows olive drab color when crushed.

The Toa silt loam is one of the best soils of the Llanos. Estimated yields of corn are 20 to 30 bushels an acre without fertilization. It is adapted also to cotton, bananas, plantains, tomatoes, okra, beans, yamas, potatoes, and a variety of grasses.

MARACAY SOILS

The Maracay soils are widely distributed along many of the streams of the Llanos. They are discussed in greater detail under the description of the Soils of the Northern Highlands.

CHURURÚ SOILS

The Chururú soils occur along some of the larger streams near the point where they debouch from the highlands. They occur also along streams within the highland areas. They are discussed under Low Terrace and Stream Bottom Soils of the Western Highlands.

Calcareous group

LA MIEL SOILS

The La Miel soils are calcareous terrace soils occurring in the western part of the Llanos, along the larger streams near the mountains. They are very dark gray or black in the surface section and greenish-brown to brownish-yellow in the subsoil. They are typically found at levels sufficiently high to free them from the danger of floods.

La Miel Silty Clay

The La Miel silty clay consists of about 10 or 12 inches of very dark gray to black silty clay, with calcareous mycelia-like specks and strings along root channels, underlain by greenish-brown, very friable, calcareous silty clay. At about 20 inches beneath the ground surface appears light brownish-yellow, micaceous, gritty silty clay loam, mottled with green and rust brown. In the typical soil the content of calcium carbonate exceeds 30 percent at depths of 20 to 30 inches.

The La Miel silty clay is probably the best soil of the Llanos. Adaptable crops are cotton, corn, the various legumes adaptable to the climate, tomatoes, okra, onions, cabbage, and various grasses. It occurs principally along the upper Duragua River, south of Barquisimeto.

Low Terrace and Stream Bottom Soils (poorly drained)

PORTSMOUTH SOILS

The Portsmouth soils are much the same as those so commonly present in imperfectly drained areas of the Middle Atlantic Coastal Plains in the United States.23/ They are dark gray to black poorly-drained soils occurring in depressional areas of the Llanos. These are acid lands of low fertility.

Portsmouth Loamy Fine Sand

The Portsmouth loamy fine sand consists of about 5 inches of dark gray to almost black loamy fine sand, high in organic matter and underlain by sand ranging in color from grayish-brown to pale yellow or almost white. This often extends without much change to depths of more than 4 feet. It is usually saturated, especially in the lower part, throughout the year.

23/ H. H. Bennett, The Soils and Agriculture of the Southern States, New York: The MacMillan Co., 1921.

The Portsmouth loamy fine sand is low in productivity. It is best suited to water-loving grasses for grazing. The principal areas were seen in low, wet flats of the Llanos near Haciendo Irco, in southern Táchira.

BIBB SOILS

The Bibb soils are associated with the Portsmouth, differing from them chiefly in the lighter gray color of the topsoil. They are much like the soils of the same name mapped in the first bottoms of streams of the Southeastern Atlantic-Gulf Region of the United States.24/ They are characteristically light gray surface soils overlying white or very pale yellow and light gray subsoils, frequently underlain by saturated white sand (quicksand) at about 4 feet. They are very poorly drained, occurring in depressions along the northerly edges of the Llanos. The principal areas were seen in Southern Táchira. Their only value is for grazing.

Bibb Sandy Clay Loam

The sandy clay loam consists of about 6 inches of light gray sandy clay loam, underlain by white or very pale yellow and light gray sandy clay. This second layer passes into white, plastic clay at about 12 to 14 inches and is underlain, in turn, by saturated white sand at about 4 feet below the ground surface.

The type is very wet; it is saturated most of the time. It is poor and acid and is of no use for cultivation and has only limited grazing value.

Organic Soils

MENE SOILS

The Mene soils are the only purely organic soils found in Venezuela. They occur in permanently wet depressions called morichales (from the moriche palms that grow in them).

Mene Silty Muck

The Mene silty muck consists of black silty muck about 2 to 8 feet deep. It frequently has a bluish cast and clay-like consistency in the lower part. Pure white sand is the basal material. Except for the surface 6 inches or a little more which dries out in the dry season, the profile is perpetually wet.

The type is not particularly adapted to cultivation, although fair success has been had on a small drained area near the Mene Grande Oil Company Camp at San Tomé. Its most profitable utilization probably would be for the production of moriche-palm nuts, which are very good food for hogs.

An area of dark coffee-brown to black muck or peaty muck was found in a narrow strip in a depression kept water-logged by seepage from nearby deep gravel beds underlying the terrace at Santo Domingo in southern Táchira. This occurs in association with the Uribante soil in its type locality.

SOILS OF THE HILLS AND BASINS OF LARA

Soils Derived from Old Alluvial Materials (well drained)

Calcareous group

24/ Ibid.

BARQUISIMETO SOILS

The Barquisimeto soils are characterized by vari-colored loamy soils overlying red clay subsoil. Caliche of cream color occurs generally at depths of less than 2 feet. Within a distance of 50 to 100 feet the surface soil may range from red to almost black. Commonly, a rather uniformly red, gravelly clay is encountered between depths of about 18 inches and about 3 to 4 feet. The lower, or caliche, layer ranges from about 15 to 20 inches or more in thickness. It usually is reached at depths of about 40 inches or more. The type sample shows a content of about 60 percent of calcium carbonate.

Some severely grazed patches have suffered from erosion.

The climate is too dry for cultivation, except for such dry land crops as sisal.

The Barquisimeto group of soils occupies flat, dry interhill areas of Lara and Falcón.

Barquisimeto Clay

The Barquisimeto clay consists of brownish-red to almost black clay, underlain at about 16 to 20 inches by red, very gravelly, calcareous clay. Beginning at about 2 feet cream colored caliche is encountered. This caliche goes down to the 5-foot level in many places. The color of the surface soil ranges from brownish-red to black within short distances.

Erosion on the Barquisimeto clay is for the most part only slight to moderate, but in a few overgrazed patches it is severe. The vegetative cover is very thin, as a rule, owing to overgrazing.

Under the low rainfall prevailing in the region occupied by the Barquisimeto clay, the variety of crops which may be grown is very limited. Sisal plantings ranging from poor to fairly good are to be seen near the city of Barquisimeto. This seems to be the crop most likely to succeed on this soil.

It is believed range conditions could be improved by contour-furrowing and water spreading, in conjunction with controlled grazing.

EL TOCUYO SOILS

The El Tocuyo soils, like those of the Barquisimeto group, are extremely variable. This does not mean that widely differing types have been included in the series, but that color changes and variations in the thickness of both topsoil and subsoil, and in gravel content, take place within short distances without any very great change in general profile characteristics. Probably it would be best to look upon the El Tucuyo soils as a soil complex, rather than a single definite group.

The surface soil commonly ranges in color from dark grayish-brown to black and in depth from about 8 to 26 inches. The structure of this dry soil is roughly prismatic. The subsoil is a calcareous clay ranging in color from yellowish-brown to dark brown or red, and in thickness from about 18 to 36 inches. Gravel may be present in varying quantities throughout any one or all of the horizons, and in other places no gravel may be found. More typical Horcones soils are found in the dry basin type of country in Lara and Falcón.

El Tocuyo Clay

The El Tocuyo clay surface soil to an average depth of about 10 inches is a dark, grayish-brown to black clay, roughly prismatic in structure. Below this

and extending to depths of 30 to 40 inches is a gravelly calcareous clay whose color ranges from yellowish-brown to dark brown or red. The gravel content of the subsoil varies considerably and locally may be absent.

Much of the type has been severely eroded. Both sheet and gully washing have been very active. Overgrazing of both the type and the surrounding hills have been the chief contributing factors. Not all of the type has been so affected; some of the better areas are planted to sisal and the results have been very good. There are large areas on which this valuable crop could be successfully grown.

Much of the severely eroded land has been ruined so far as cultivation is concerned. Here, the problem is one of reclamation and restoration of vegetative cover. This is a regional rather than a local problem, and until the excessive runoff from the surrounding hills is halted, or at least slowed down considerably, very little in the way of effective control can be accomplished on the flats.

QUIBOR SOILS

The Quibor soils are calcareous soils occurring in the flat basin areas of the very dry parts of Lara and Falcón.

These are calcareous, gray soils of hard, cloddy (break into fragments several inches thick) structure. The subsoils are also of gray color and heavy texture to depths of 2 or 3 feet, where the texture becomes somewhat lighter and gravelly. This lower part may or may not be calcareous.

Erosion is generally serious and the vegetation is of poor quality. These soils are too poor for cultivation and are only slightly better for grazing.

Quibor Silty Clay

The Quibor silty clay consists of about 8 to 10 inches of hard, cloddy (when dry), calcareous silty clay of gray color. Below this depth the clay is of lighter gray color but otherwise not markedly different. At depths of about 2 or 3 feet the subsoil grades into gray silty clay loam containing varying amounts of gravel.

Areas of several acres occur here and there that are bare of vegetation. These areas have the same general appearance as alkali flats in the western part of the United States of North America.

Erosion conditions are serious over much of the type, owing to land abuse so prevalent in the region. Controlled grazing would be of some benefit, but the Quibor soils may not be easy to revegetate. In their present condition they are very nearly worthless.

<u>Non-calcareous group</u>

CARORA SOILS

The Carora soils occur as terrace or old stream-bed soils rather than on recently formed alluvial plains. The surface is not so flat as the regular alluvial plains. Stones are abundant over the surface and throughout the profile. In places 50 to 75 percent of this material consists of rounded boulders and gravel.

These lands have been heavily overgrazed by goats, but because of their stony character they have not suffered greatly from erosion. Controlled grazing is the best use, although some fence posts and fuel could be derived from forested areas. This group is of fairly wide extent in the dry regions of Falcón and Lara.

Carora Stony Loam

The Carora stony loam is composed of about 25 percent of fine soil material, chiefly yellowish-brown sand, and about 75 percent of large water-rounded gravel and boulders ranging up to 15 inches or more in diameter.

The land is unsuitable for cultivation and because of its very stony character supports very little vegetation of grazing value. It has been severely overgrazed by goats but has suffered little from erosion because of the protection afforded by the stones. With good range management it is entirely likely that grasses, to some degree, would come back.

LOS ARANGUES SOILS

The Los Arangues soils are of limited extent, having been seen only in the somewhat more humid basins of Lara about 35 kilometers south of Carora. They are important because they represent the largest single body of good soils in an area where even fair farm land is at a premium.

Although these soils were cultivated in the past, they are now largely unused for tilled crops. Until proper land management is established on the surrounding hills there will be little opportunity for further practical utilization.

The Arangues soils are of brown color to depths of about 16 or 18 inches. Below this upper layer occurs yellowish-brown sandy clay loam or clay, which extends to depths of 3 feet or more. Cotton, corn, sugar cane, and many vegetables may be expected to succeed under irrigation.

Los Arangues Clay Loam

The Los Arangues clay loam consists of brown clay loam about 16 to 18 inches deep, overlying yellowish-brown sandy clay loam extending to depths of 3 feet or more.

This is a good soil for farming purposes. It has been cultivated in the past but constantly diminishing irrigation-water supply forced the discontinuance of farming operations. Its present best use is for grazing, but with a restored water supply it could be successfully used for such crops as cotton, corn, sugar cane, onions, tomatoes, beans, okra, and peppers.

Residual Soils (well drained)

BARBACOAS SOILS

The Barbacoas soils are very stony and open natured. They are derived from sandstone similar to that from which the Bramón and La Cruz soils are derived. Temperatures are relatively high and the rainfall somewhat above that for most of the Hills and Basins country. Vegetation is largely forest, intermediate between the dry and humid types.

Though liberally grazed, the Barbacoas soils have suffered very little from erosion. Their stony character has served to hold most of the finer soil material in place. They are valuable only for grazing and for the production of forest products like fence posts and fuel.

Barbacoas Stony Sand

The surface 6 inches of the Barbacoas stony sand is brown sand with a reddish cast. Below this occurs very gravelly, faintly reddish-brown sand, which becomes faintly yellowish-brown at depths of about 18 inches below the ground surface. Many boulders of all sizes, ranging upward to 10 feet in diameter are present on the ground and throughout the profile.

Very little erosion is in evidence, even though heavily grazed in many places. This lack of erosion is due to the very stony nature and to consequent high porosity and capacity for rainfall infiltration.

The most economic use is for forest, such as would supply some fuel and also afford watershed protection. Grazing should be rigidly controlled. This would permit some recovery of the grasses and other low growing plants, and thus provide increased watershed protection and better grazing.

SOILS OF THE MARACAIBO BASIN

Soils Derived from Old Water-lain Materials (well drained)

CABIMAS SOILS

The Cabimas soils are found principally in the moderately heavily forested plains sections of the Maracaibo Basin. The surface soils are light brown and usually very sandy, and the subsoils are yellowish-brown in color and usually of clay or sandy clay texture. Both surface soil and subsoil are of acid reaction.

They are of broad extent in the Maracaibo Basin and also occur in the semi-desert areas of the Falcón coast. Their agricultural value is low.

Cabimas Fine Sandy Loam

The Cabimas fine sandy loam is a light brown to light reddish-brown fine sandy loam, underlain at about 8 or 10 inches by brown sandy clay loam or sandy clay. Beneath this and continuing to depths of 30 inches or more is yellowish-brown sandy clay containing moderate amounts of small black concretions.

None of this land was seen in clean cultivation. One small field of gamelote grass looked fairly well. It is not recommended for general cultivation. If gamelote, Guinea, and other drought resistant grasses can be grown successfully, grazing might be of some importance. Grain sorghums might do well if planted before the end of the rainy season.

A variety of the Cabimas fine sandy loam consists of light brown fine sandy loam about 6 inches deep, overlying light yellowish-brown, compact fine sandy loam extending to a depth of 3 feet or more. Very little of this type is in cultivation. Plantings of gamelote grass were doing fairly well.

INCIARTE SOILS

The Inciarte soils are found in the moderately heavily forested sections of the Maracaibo Basin. The surface soils are reddish-brown to red, with a rather wide textural range. The subsoils are brick-red in color and usually of clay and clay loam texture, rather compact in the upper part and friable below depths of about 30 inches.

Inciarte Fine Sandy Loam

The Inciarte fine sandy loam consists of about 4 to 6 inches of reddish-brown friable fine sandy loam, underlain by brick-red compact clay loam, which at about 2 feet is underlain by brick-red, friable clay extending to depths of about 5 feet.

A considerable amount of land occupied by this type of soil was recently cleared along the oiled highway from Maracaibo to Villa Rosario. The only plantings noted were gamelote grass and yuca, both of which looked very good. Because of the relatively low rainfall and its unfavorable distribution, intensive farming operations are not recommended. With good soil management, however, it is believed fairly good results may be had in growing various grasses and sorghums for livestock.

MONAY SOILS

The Monay soils are commonly heavy-textured soils found under moderately heavy forest in the Maracaibo Basin and on the terraces around Lake Valencia. The surface 4 to 6 inches is grayish-brown in color; below this is brownish-yellow to brownish-red clay.

Monay Silty Clay

The Monay silty clay is a grayish-brown silty clay underlain at 5 or 6 inches by brownish-yellow clay, which passes at about 2 feet below the surface level of the land into brownish-red silty clay. This lower section extends to depths of about 5 feet without any considerable change in its dominant physical character. The lower part, however, is commonly yellow in color.

None of the type was seen under cultivation but some rather large areas in rastrojo show that portions were formerly cultivated.

During the rainy season this soil should produce various crops adaptable to the climate. With irrigation it should give good results with rice.

Monay Clay

The Monay clay is characterized by 6 or 7 inches of brownish-gray, micaceous clay with a yellowish cast (the yellowish color being more apparent when fragments of the soil are crushed), underlain by brownish-yellow, highly micaceous, friable silty clay. Below about 20 inches the material becomes more grayish in color and more micaceous. When sufficiently disturbed this lower section of silty clay breaks up into irregularly shaped fragments coated with gray. These have a reddish-yellow color when crushed. The mica is very finely divided and imparts a greasy feel to the soil material when it is moist enough to be compressed between the fingers. In places the soil bakes and hardens in the dry season.

The Monay clay was first encountered on Hacienda Mariposa, about 1,200 feet south of the old road from Valencia to Tocuyito.

This is a good agricultural soil adapted to most of the lowland crops grown in Venezuela.

Monay Silty Clay Loam

Monay silty clay loam was found on the Valencia Irrigation Project. It differs from the clay type only in the texture of the surface soil and in having somewhat better porosity.

Crop value is a little better than that of the Monay clay, and the soil is somewhat easier to keep in good condition of tilth.

GUACARA SOILS

The Guacara soils are discussed under Soils of the Northern Highlands. Here in the Maracaibo Basin, because of higher rainfall and shorter dry season, these soils are capable of a greater use without irrigation. However, they are not recommended for general agriculture, but are suitable for the production of grasses for hay and pasture.

Between kilometer 30 on the National Railways and El Vigia, to the east, most of the country is occupied by these sandy lands. Sandy loam and loamy sand are the predominant types in the region.

MARACAY SOILS

The Maracay soils are more fully discussed under the Soils of the Northern Highlands. Large areas of the very fine sandy loam, silt loam, and clay types occur in the Maracaibo Basin. They are generally acid rather than alkaline as in the Lake Valencia area -- more like the variety of Maracay soils found along the rivers of the Llanos and along the lower Yaracuy.

Low Terrace and Stream Bottom Soils

ENCONTRADOS SOILS

The Encontrados soils are heavy-textured soils occurring in the very humid sections of the Maracaibo Basin. They are yellowish-brown in color, mottled with rust brown, underlain at about 18 to 24 inches by gray heavy clay which extends to a depth of 4 feet or more.

They are sometimes flooded during the rainy season.

Encontrados Silty Clay

The Encontrados silty clay consists of about 3 inches of yellowish-gray silty clay, mottled with brown and underlain by yellowish-brown silty clay mottled with rust brown and yellow. This, in turn, is underlain at depths of about 20 inches below the ground surface by gray heavy clay mottled with brown.

A considerable part of the type is covered with shallow depositions of silt derived from annual overflows from the streams.

Much of the type is planted to Para grass, which gives excellent results. Here this grass furnishes some of the finest pasture seen in the entire Republic.

It is believed that excellent results could be had with rice on these lands. Optimum conditions for rice growing -- soil, climate, available water supply, and markets -- are all here. A likely difficulty would be the presence of rice -- eating birds, but some method should be found for overcoming this -- just as rice growers in other parts of the world have met the problem.

Other Soils of the Maracaibo Basin

Other soils found in the Maracaibo Basin are described under Soils of the Llanos; namely, Ruston, Palenque, Barinas, Guárico, Tamanaco, Toa and Uribante groups.

SOILS OF THE COASTAL REGION OF FALCÓN

Low Terrace and Stream Bottom Soils

CORO SOILS

The Coro soils are developed on alluvial flats and low associated terraces along the coast line. They are highly calcareous, probably contain alkali, and are heavy textured. Color is yellowish-brown in the upper 15 to 20 inches and light brown below that depth.

Because of the low rainfall they can be cultivated only if irrigated. These soils were seen in cultivation only at the Experiment Station at Coro. Here excellent results were obtained with milo maize and Sudan grass under irrigation. Cocoanut palms planted for wind breaks are producing good crops under irrigation. Local information indicates that irrigated cocoanuts are not normally a profitable crop.

These lands are best suited for the production of forage crops and grasses for livestock, where irrigation water is available. Without irrigation they are practically useless for agricultural purposes. With moderate grazing they would support fair stands of drought resistant grasses.

Coro Silty Clay

The Coro silty clay consists of about 20 inches of light yellowish-brown, highly calcareous silty clay containing occasional mollusk shells. Below this and extending to a depth of about 3 feet occurs light-brown highly calcareous silty clay containing a few soft brown concretions and mollusk shells. During the dry season the surface cracks deeply, often to a depth of 2 feet. The unirrigated soil has little value aside from scant grazing. But with irrigation various grasses could be grown for livestock.

Eolian Soils

CUMAREBO SOILS

The Cumarebo soils are red, sandy soils developed on old dunes under low rainfall conditions, alternate wet and dry seasons and high temperatures. Although of limited extent and low natural fertility, land of the Cumarebo type is of great importance. Most of the Zabila or aloes produced in Venezuela is grown on this soil. It is extremely doubtful, however, if it would grow any other crop.

Because of its loose nature, water erosion is very slight. When cleared, however, it is highly susceptible to wind erosion.

The manner of growth of the Zabila -- suckering and spreading -- makes it an excellent wind-erosion-control plant and where grown not much damage takes place.

Cumarebo Fine Sand

The Cumarebo fine sand to a depth of about 2 feet consists of yellowish-red, loose, fine sand, below which occurs brick-red, loose, fine sand that extends to depths of 40 inches or more. The only apparent value is for growing Zabila.

Other Soils

Several other soils, discussed in other parts of this report, are found in the Coastal Region of Falcón. Members of the following groups were observed: Cabimas, Maracay, Vega Baja, Carora, Palenque, El Tocuyo, Quibor, Barquisimeto, Capacho, Loma, Palacio, Guanta, Tucupido, Guárico, Bramón, and La Cruz.

APPENDIX

Physical and chemical analysis and pH determination of some representative soils of Venezuela.

Table 1. - Determination of Carbonates in Soils 1/

Soil Type	Depth	Carbonate expressed as calcium carbonate
	Inches	Percent
Barcelona silty clay	0-26	0.02
" " "	26-48	1.55
Barquisimeto clay	0-18	.38
" "	18-42	3.82
" "	42-60	61.06
Camoruco clay	0-23	none
" "	23-30	.50
" "	30-46	.01
Capacho clay	0-16	.03
" "	16-28	.14
Charallave clay	0-6	.01
" "	6-19	.05
" "	19-36	.07
" "	36-60	23.34
Coro silty clay	0-20	1.10
Guanta silt loam	0-8	36.78
" " "	8-28	46.89
" " "	24-30	63.88
El Tocuyo clay	0-10	.18
" " "	10-36	1.17
La Miel silty clay	0-12	11.13
" " " "	12-20	28.75
" " " "	20-30	36.82
La Puerta clay loam	0-10	.20
" " " "	10-28	.02
" " " "	28-36	.06
Loma silty clay	0-6	.03
" " "	6-26	.01
" " "	26-36	.03
" " "	36-60	8.66
Palacio clay	0-14	.07
" "	14-48	6.43
Quibor clay	0-8	6.88
" "	8-32	9.16
Valencia silty clay loam (shallow phase)	0-5	26.10
" " " " " "	5-18	27.18
" " " " " "	18+	49.91
Taborda silty clay loam	0-5	.05
" " " "	5-12	.01
" " " "	12-26	.02
" " " "	26-36	.11
Tucupido clay	0-24	0.01
" "	24-32	.01
" "	24-32	16.46 % calcium sulfate 2/
Valencia clay from Urena Experiment Station in Táchira	0-8	.03
" " " " " "	8-24	3.79
Valencia silty clay loam 3/	0-12	5.34
" " " " 3/	12-32	5.65
" " " " 3/	32-44	6.21
" " " " 4/	0-24	8.71
" " " " 4/	24-38	7.79
" " " " 5/	0-14	15.98
" " " " 5/	14-30	17.57
" " " " 5/	30-60	15.49

Table 1. - Cont'd.

1/ Analysis by W. Dill. Determined by Schollenberger method. Schollenberger, C. J. Determination of carbonates in soil. Soil Sci. 30: 307-324, 1930.

2/ Analysis by Joe Schelling.

3/ Sample from Manzanares River 4 km south of Cumaná.

4/ Sample obtained 16 km S.E. of Maracay, Ven., 2 km from Turmero River.

5/ Sample obtained at Exp. Station at Barquisimeto, Lara, Ven.

Table 2. - Mechanical Analysis of Topsoils1/

Soil Type	Total sand 2-.05 mm	Total silt .05-.002 mm	Total clay .002 mm
	%	%	%
Adolfera silty clay loam	5.29	49.66	45.05
Barinas fine sandy loam	62.56	17.10	20.34
Barquisimeto clay	38.05	27.00	34.95
Cabimas fine sandy loam	48.02	27.85	24.13
Canoa loamy sand	72.59	18.21	9.20
Tovar clay loam	27.96	39.33	32.71
Caripito sandy loam	71.58	14.77	13.65
Cumarebo fine sand	78.13	16.77	5.10
Encontrados silty clay	7.96	55.73	36.31
La Miel silty clay loam	34.96	36.48	28.56
Monay silty clay loam	3.01	47.77	49.22
Maracay very fine sandy loam	66.60	26.81	6.59
Mene silt loam	31.09	47.83	21.08
Mucuchies gritty loam	61.84	29.42	8.74
Obispos very fine sandy loam	40.94	48.02	11.04
Lobatera fine sandy loam	53.81	24.69	21.50
Guataparo sandy clay loam	51.00	24.53	24.47
Guataparo silty clay loam	28.49	37.18	34.33
San Felipe loam	60.58	28.36	11.06
Tamanaco fine sandy loam	59.40	27.97	12.63
Tamanaco silty clay loam	28.92	37.27	33.81
Vega Baja loam	60.14	24.83	15.03
Valencia silty clay loam2/	16.87	54.96	28.17
Zumbador silty clay loam	21.66	40.84	37.50

1/ Analysis by J. Schelling. Determined by pipette method.

2/ 16 km. S.E. of Maracay, Ven., 2 km. from Turmero River.

Table 3. - Determination of Total Water Soluble Salts1/

Soil Type	Depth	Soluble salts	
	Inches	Percent	p.p.m.
Barcelona silty clay	0-26	0.589	5886.2
" " "	26-48	.843	8428.1
Coro silty clay	0-20	.291	2905.1
" " "	20-36	.488	4879.9
Cumaná loamy fine sand	0-14	.733	7326.1
" " " "	14-21	1.758	17578.4
" " " "	21-41	1.997	19966.8
Maracay very fine sandy loam	0-16	.162	1616.4
" " " " "	16-26	.173	1725.3
" " " " "	26-30	.179	1792.0
" " " " "	30-36	.156	1555.0
Quibor silty clay loam	0-8	.181	1805.6
" " " "	8-32	.250	2497.6
Valencia silty clay2/	0-20	.107	1067.1
" " "	20-60	.754	7543.9

1/Analysis by Lee Lumpkin.

2/Sample collected at Barquisimeto Experiment Station for soluble salt analysis.

Table 4. - Determination of Organic Matter in Topsoils1/

Soil Type	% Organic Matter2/
Adolfera silty clay loam	1.82
Bailadores gritty loam	2.26
Barcelona silty clay	2.79
Barquisimeto clay	1.55
Canoa loamy sand	.85
Capacho clay	2.96
Tovar clay loam	4.12
Caripito sandy loam	1.86
Charallave clay	3.29
Cumarebo fine sand	.85
Encontrados silty clay	3.74
Ocumare clay	1.85
La Miel clay loam	3.69
Monay silty clay	3.65
La Puerta clay loam	2.41
Loma silty clay	3.58
Monay clay	3.34
Maracay very fine sandy loam	1.09
Mene silty muck	9.34
" " "	8.58
" " "	8.85
" " "	.56
Mucuchies gritty loam	5.42
Obispos very fine sandy loam	1.24
Guarico fine sandy loam	2.29
Palacio clay	.95
Lobatera fine sandy loam	3.52
Paya silty clay	2.48
Valencia silty clay loam (shallow phase)	17.33
Quiriquire silt loam	2.58
Guataparo sandy clay loam	2.33
" silty " "	2.68
San Felipe loam	6.06
Tamanaco silty clay	3.12
Táchira clay	.68
Tarbera clay	2.07
Valencia clay from Urena Experiment Station in Táchira	2.31
Valencia silty clay3/	5.09
Zumbador silty clay	3.23

1/Analysis by Joe Schelling.
2/Determined by Chromic acid method. Schollenberger, C. J. Determination of soil organic matter Soil Sci. 31: 483-486. 1931.
3/Profile sampled 16 km. S.E. of Maracay, 2 km. from Turmero River.

Table 5. - pH values of topsoil1/

Soil Type	pH
Adolfera silty clay loam	7.05
Bailadores gritty loam	5.65
Barcelona silty clay	6.4
Barquisimeto clay	8.0
Canoa loamy sand	5.4
Capacho clay	6.6
Caracas clay loam	5.6
Caripito sandy loam	7.85
Charallave clay	6.45
Cumarobo fine sand	7.5
Encontrados silty clay	5.9
Ingenio clay	5.5
La Miel clay loam	8.0
Lagunillas silty clay	6.0
La Puerta clay loam	7.2
Loma silty clay	7.55
Maracay clay	5.0
Maracay very fine sandy loam	5.2
Mene silt loam 0-6"	4.5
" " " 6-24"	4.2
" " " 24-72"	4.0
" " " 72+"	3.7
Mucuchies gritty loam	5.0
Obispos very fine sand loam	4.95
Ortiz fine sandy loam	4.65
Palacio clay	6.9
Palmira fine sandy loam	5.95
Paya silty clay	4.5
Quinta silty clay loam	7.8
Quiriquire silt loam	4.30
San Carlos sandy clay loam	4.85
" " silty " "	5.55
San Felipe loam	6.1
Tamanaco silty clay	5.20
Táchira clay	5.3
Tarbera clay	5.20
Urena clay	6.9
Valencia silty clay2/	7.65
Zumbador silty clay	4.85

1/ Analysis by T. Kirkpatrick. Determined electrometrically on air dry samples using the glass electrode.

2/ Profile sampled 16 km. S.E. of Maracay, 2 km. from Turmero River.

NAMES OF CERTAIN SOILS HAVE BEEN

CHANGED - SEE NOTE BELOW

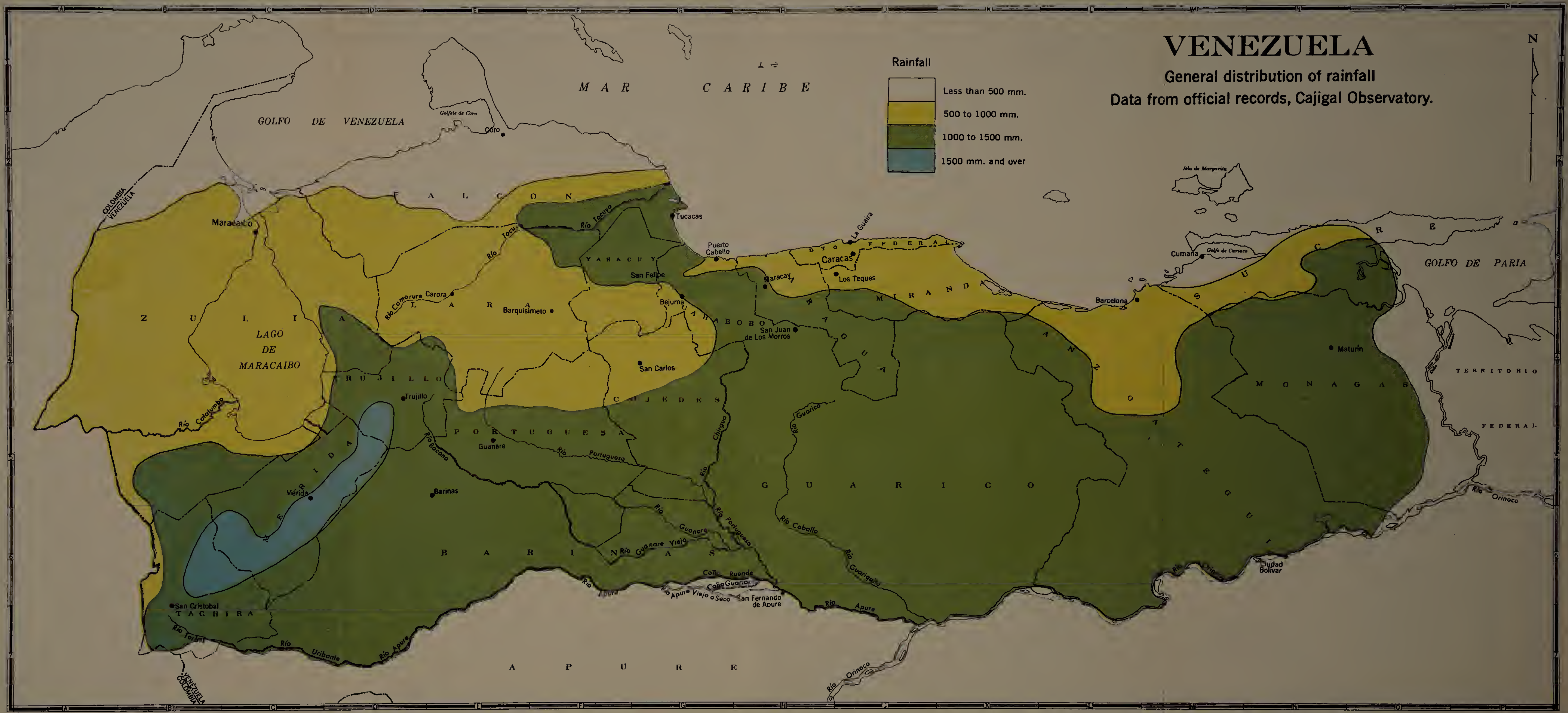
Caracas clay loamshould be changed to Tovar clay loam; Ingenio clay to Ocuma clay; Lagunillas silty clay to Monay silty clay; Maracay clay to Monay clay; Orti fine sandy loam to Guarico fine sandy loam; Palmira fine sandy loam to Lobatera f sandy loam; Quinta silty clay loam to Valencia silty clay loam, shallow phase; Sa Carlos sandy clay loam to Quataparo sandy clay loam; San Carlos silty clay loam t Guataparo silty clay loam; and Urena clay to Valencia clay.

CONTENTS

Maps of Venezuela

★ ★ ★


VENEZUELA
Itinerary of Soil Conservation Commission, 1942.
Route followed
MAR CARIBE
GOLFO DE VENEZUELA
Golfete de Coro
Coro
FALCON
Tucacas
Puerto Cabello
La Guaira
Caracas
Los Teques
DTO. FEDERAL
MIRANDA
Isla de Margarita
Cumana
Golfo de Cariaco
SUCRE
GOLFO DE PARIA
Barcelona
Maturín
MONAGAS
ANZOATEGUI
TERRITORIO FEDERAL
Río Orinoco
Ciudad Bolivar
Maracaibo
COLOMBIA
VENEZUELA
ZULIA
LAGO DE MARACAIBO
Río Catatumbo
Río Tocuyo
Río Camorure
Carora
LARA
Barquisimeto
YARACUY
San Felipe
Bejuma
CARABOBO
Maracay
ARAGUA
San Juan de Los Morros
San Carlos
COJEDES
TRUJILLO
Trujillo
PORTUGUESA
Guanare
Río Portuguesa
Río Boconó
Barinas
Mérida
MERIDA
BARINAS
Río Guanare
Río Guanare Viejo
Río Chirgua
Río Guarico
GUARICO
Río Cobollo
Río Guariquito
Caño Ruende
Caño Guoriopa
Río Apure
Río Apure Viejo o Seco
San Fernando de Apure
San Cristobal
TACHIRA
Río Torbes
Río Uribonte
APURE
Río Orinoco



VENEZUELA
General distribution of rainfall
Data from official records, Cajigal Observatory.
Rainfall
Less than 500 mm.
500 to 1000 mm.
1000 to 1500 mm.
1500 mm. and over
MAR CARIBE
GOLFO DE VENEZUELA
GOLFO DE PARIA
LAGO DE MARACAIBO
ZULIA
FALCON
LARA
YARACUY
CARABOBO
ARAGUA
MIRANDA
TRUJILLO
PORTUGUESA
COJEDES
MERIDA
TACHIRA
BARINAS
GUARICO
ANZOATEGUI
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Maracaibo
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San Felipe
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Carora
Barquisimeto
San Carlos
San Juan de Los Morros
Trujillo
Guanare
Mérida
Barinas
San Cristobal
San Fernando de Apure
Barcelona
Cumana
Maturín
Ciudad Bolívar
Río Orinoco
Río Apure

MAJOR LAND TYPES, VENEZUELA (RECONNAISSANCE)

Miles & Kilometers

0 10 20 30 40 50 60 70 80 Kilometers

0 10 20 30 40 50 60 70 80 Miles

SHEET 2

LEGEND-TABLA

	Paved roads	(Carreteras pavimentadas)
	Oiled roads	(Carreteras petrolizadas)
	Roads passable entire year	(Carreteras traficables todo el año)
	Roads passable dry season only	(Carreteras de verano)
	Trails	(Senderos o veredas)
	Approximate distances in kilometers	(Distancias aproximadas en kilómetros)
	State Boundaries	(Límites de los Estados)
	State Capitals	(Capitales de Estados)
	District Capitals	(Capitales de Distritos)
	Other cities and towns	(Otras ciudades y pueblos)
	Postoffices	(Oficinas de Correos)
	Telegraph Offices	(Oficinas de Telégrafo)
	Postoffices and Telegraph Offices	(Oficinas de Correos y Telégrafo)
	Oilfields	(Campos de petróleo)
	Railroads	(Ferrocarriles)
	Air Lines	(Líneas Aereas)
PAA	Pan American Airways	
LAV	Venezuelan Airmail Line	(Línea Aeropostal Venezolana)
KLM	Royal Netherlands Aviation Company	(Compañía Real Holandesa de Aviación)
	Commercial Airfields	(Aeródromos comerciales)
	Airports	(Aeropuertos)
	Municipal or Private Airfields	(Aeródromos Municipales o Privados)

THE HIGHLANDS
TIERRAS ALTAS

1

Severely Eroded Mountainous Country (humid climate)
Generally unsuited to cultivation
Susceptible to very rapid erosion

Montañas Fuertemente Erosionadas (clima húmedo)
Generalmente No adaptables para cultivos.
Con tendencia a erosión muy rápida.

2

Severely Eroded Mountainous Country (dry)
Generally unsuited to cultivation
Susceptible to severe erosion

Montañas Fuertemente Erosionadas (clima seco)
Generalmente no adaptables para cultivos.
Con tendencia a erosión fuerte.

3

San Cristóbal Basin (humid)
Much land estimated (65 to 75%) favorable for agriculture. Susceptible to erosion at moderate rates

Cuenca de San Cristóbal (clima húmedo)
Se calcula que bastante tierra (de 65 a 75%) es propicia para la agricultura. Con tendencia a erosión en proporción moderada.

4

Steep Mountain Land (humid)
Slopes predominantly 35 to 60%, with many areas in excess of 60%. Original forest mostly removed. Considerable farming on favorable shelving positions; too much on steep slopes. Estimated 80% too steep for cultivation and in need of reforestation. Susceptible to severe erosion.

Tierras Montañosas Empinadas (clima húmedo)
Predominan los declives de 35 a 60% de inclinación con muchas en exceso de 60%. Los montes primitivos son casi todos denudados. Hay bastantes cultivos en puestos favorables, aunque inclinados. Laderas muy empinadas son cultivadas en demasía. Se calcula que el 80% de las tierras están demasiado inclinadas para cultivos y deberían ser reforestadas. Con tendencia a erosión fuerte.

4

Steep Mountain Land (humid); mainly forested
Slopes predominantly 35 to 60%. Generally very little cultivation. Some coffee plantings and an occasional conuco. Estimated 80% too steep for cultivation and should remain in forest. Susceptible to severe erosion.

Tierras Montañosas Empinadas (clima húmedo; casi todas cubiertas de bosques)
Los declives de 35 a 60% de inclinación predominan. Generalmente hay pocos cultivos: algunas plantaciones de café y unos cuantos conucos. Se calcula que el 80% de las tierras están demasiado inclinadas para cultivos y deberían permanecer en monte. Con tendencia a erosión fuerte.

5

Very Steep Mountain Land (humid)
Mostly not forested. Estimated 50 to 60% or more consists of cliffs and near-cliffs. Largely non-arable or inaccessible. Occasional conuco; some grazing. Susceptible to severe erosion.

Tierras Montañosas Muy Empinadas (clima húmedo)
Por muy poco bosques. Se calcula que del 50 al 60% o más se componen de riscos o de pendientes excesivamente empinadas. La mayor parte no son cultivables o están aisladas. Unos cuantos conucos; [illegible] ganadería. Con tendencia a erosión fuerte.

6

Moderately Steep Mountain Land (subhumid)
Generally not heavily forested. Includes more shelving positions suitable for farming than Very Steep Mountain Land and much less cliff and near-cliff land. Extensively used for grazing, along with some farming. Not so susceptible to erosion as Steep Mountain Land, under prevailing methods of use. Estimated 75% too steep for farming. Slopes predominantly 25 to 50%, with little over 60%.

Tierras Montañosas No Muy Empinadas (clima semi-húmedo)
Generalmente sin bosques tupidos. Entre estas hay mas tierras de pendiente moderada adecuadas para cultivo que en las Tierras Montañosas Muy Empinadas, y hay tambien menos tierras riscosas y escarpadas. Utilizadas extensivamente para ganadería, con pocos cultivos. En el [illegible] actual no son tan erosionables como las Tierras Montañosas Empinadas. Se calcula que el 75% son demasiado inclinadas para cultivos. Los declives de 25 a 50% de inclinación predominan con algunos en exceso de 60%.

7

Páramo (humid)
Steep highlands, small plateaus, and stony peaks above timber line. Largely grassed. Used only for grazing.

Páramo (clima húmedo)
Tierras altas muy inclinadas, pequeñas altiplanicies y picos pedregosos sobre el límite de la vegetación forestal. En gran parte cubiertas de hierba. Utilizadas únicamente para pastoreo.

8

Caucagua Hills (humid)
Predominantly foothill country, with considerable possibility for cultivation under conservation practices. Characterized by good rainfall conditions. Originally heavily forested, but on cultivated area mostly covered with rastrojo. Susceptible to impoverishing erosion.

Las Lomas de Caucagua (clima húmedo)
La mayor parte son colinas al pie de las montañas, con bastante posibilidad de cultivo con prácticas conservadoras. Caracterizadas por buenas lluvias. Originalmente densamente cubiertas de bosques, pero casi todas las áreas no cultivadas están actualmente cubiertas de rastrojo. Se pueden empobrecer muy rápidamente por erosión.

9

High Mountain Valleys and Adjacent Lower Slopes (humid)
Generally steep. Estimated about 75% cultivated, but only about 40% suitable for cultivation, even with efficient conservation practices. Originally forested. Uncultivated and mostly covered with rastrojo. Slopes susceptible to destructive erosion.

Los Valles de Gran Altitud en las Montañas y Laderas Cercanas (clima húmedo)
Generalmente empinadas. [illegible] 75% del área se cultiva, [illegible] sólo el 40% es adecuada para cultivos, [illegible] prácticas conservadoras. Originalmente cubiertas de bosques. Tierras no cultivadas actualmente están, en su mayor parte, cubiertas de rastrojo. Los declives tienen tendencia a erosión destructiva.

10

Rough Stony Low Mountain Land (humid)
Characterized by numerous cliffs, abundance of large stones (up to about 10 feet in diameter), and steep slopes. Considerable hand cultivation among the rocks, which have served to impede erosion.

Tierras Escabrosas y Pedregosas de Montañas Bajas (clima húmedo)
Caracterizadas por un gran número de riscos, peñascos (hasta 3 metros de diámetro) y declives empinados. Bastantes cultivos entre las rocas, las cuales han impedido la erosión.

11

Low Mountains (humid)
Very little farming. Much rather dense forest. Susceptible to severe erosion.

Montañas Bajas (clima húmedo)
Muy pocos cultivos. Mucho monte [illegible]. Con tendencia a [illegible] erosión fuerte.

12

Rolling Benchlands and Lower Slopes of Adjacent Mountains largely covered with rainforest (very humid)
Susceptible to erosion.

Tierras Abancaladas Ondulantes y Laderas Bajas de las Montañas Cercanas [illegible] de selvas (clima muy húmedo)
Con tendencia a erosión.

13

Savanna Hills (Subhumid to Humid)
Low, rounded hills lying chiefly between the Llanos and the mountains. Natural grasslands, with scattered savanna type of tree. Shallow soil not cultivable for the most part, but used for grazing. Considerable rainfall, but soil droughty. Most of the hills less than 100 feet high above associated low land. Much erosion.

Lomas de Sabana (clima semi-húmedo a húmedo)
Colinas bajas y redondeadas situadas la mayor parte entre los Llanos y las montañas. Pastos naturales con árboles del tipo "sabana." Suelos de poca profundidad, no cultivables en su mayor parte, pero utilizados para ganadería. Bastante lluvia, pero el suelo es seco. La mayoría de las cerros tienen menos de trescientos pies de altura sobre las tierras bajas. [illegible] mucha erosión.

14

Savanna Mountains (Subhumid to Humid)
Considerably higher than Savanna Hills, and generally lower than Moderately Steep Mountain Land. Rounded configuration with but little rugged terrain. Very little farming, mostly grazing. Natural grassland, with scattered savanna type of trees. Considerable rainfall, [illegible]. Much erosion.

Montañas de Sabana (clima semi-húmedo a húmedo)
Bastante mas altas que [illegible] generalmente mas [illegible] montaña [illegible] tierras [illegible] zadas para [illegible] cuantos árboles [illegible] sol [illegible].

15

Old Eroded Terraces (Subhumid)
Predominantly low hilly topography. Very little cultivation; considerable grazing. Uncultivated areas covered with dry forest, containing few large trees. Moderate rainfall. Susceptible to erosion.

Terrazas Antiguas Erosionadas (clima semi-húmedo)
Cerros bajos predominan en la topografía. Algunos cultivos; bastante ganadería. Areas no cultivadas cubiertas de bosques de tipo seco con unos cuantos árboles grandes. Lluvias en mayor o menor grado. Con tendencia a la erosión.

16

Rolling Alluvial Terraces (subhumid to humid)
Moderate rainfall. About 10% cultivated; remainder in rastrojo. Susceptible to erosion.

Terrazas Aluviales Onduladas (clima de semi húmedo a húmedo)
Lluvias moderadas. Se calcula que el 10% está bajo cultivo; el resto en rastrojo. [illegible] tendencia a la erosión.

17

High Mountain Slopes and Valleys (humid)
Wheat Belt
Steep, high mountain slopes, with narrow high valleys, associated Benchlands, and talus slopes. Used extensively for wheat. High rainfall (70 inches or more). Much erosion.

Laderas y Valles de las Montañas Altas (clima húmedo). Area Triguera
[illegible] muy empinados de la montaña [illegible] estrechos y banca[illegible] declives [illegible] el trigo. Mucha [illegible] pulgadas [illegible]
Mucha erosión.

HILLS AND BASINS OF LARA
CERROS Y CUENCAS DE LARA

18

Rough Hill Country (Subhumid)
Predominantly forested. Rainfall moderate to heavy. Generally not cultivable. Susceptible to erosion.

Tierras Quebradas (clima semi-húmedo)
Estan en la mayor parte cubiertas de bosques. La lluvia es por medio entre moderadas y bastantes. Generalmente no son cultivables. Con tendencia a erosión.

19

Rounded Hills and Low Mountains (dry to subhumid)
Pebbles and boulders abundant over surface. Almost no cultivation. Vegetation intermediate between dry-forest and humid forest. Not much erosion.

Cerros [illegible] y Montañas Bajas (clima seco a semi-húmedo)
[illegible] piedras abundan sobre la superficie. Casi sin ningun cultivo. Vegetación de tipo intermedio entre montes secos y montes húmedos. [illegible]

21

Old Terrace Lands and Filled-in Basins (dry—Barquisimeto type)
Used for grazing and sisal. Dry country: abundance of semi-arid vegetation, including cacti. Susceptible to destructive erosion.

Terrazas Antiguas y Cuencas Rellenadas (clima seco, tipo Barquisimeto)
Dedicadas a la ganadería y al sisal. Abunda la vegetación semi-árida, incluyendo el cactus. [illegible] tendencia a erosión destructiva.

20

Severely Eroded Low Hills (dry)
Associated with Barquisimeto type of Basin country. Dry-forest vegetation; predominantly scanty growth of small trees and cacti. Used only for grazing. Susceptible to destructive erosion.

Cerros Bajos Fuertemente Erosionadas (clima seco)
[illegible]

COASTAL REGION OF FALCÓN
(Predominantly [illegible])
REGION COSTANERA DE FALCON
(Predominantemente [illegible])

22

Coastal Hill Country (subhumid to humid)
Rainfall gradually increases from west to east, with accompanying change in vegetation from thin stands of dry forest to near rain forest. Considerable cultivation. Some grazing. Erosion locally severe.

Región de Cerros [illegible] (clima de semi húmedo a húmedo)
Las lluvias aumentan gradualmente de oeste a este con el correspondiente cambio en la vegetación, de monte seco a casi pluviselva. [illegible] ganadería. [illegible] la erosión es aguda.

MARACAIBO BASIN
CUENCA DE MARACAIBO

23

Nearly Level Plains (semi-desert)
Rainfall less than 20 inches; locally not over 10 inches. Thinly vegetated. Very little cultivation.

Llanuras [illegible] Planas (clima de semi desierto)
Lluvias menos de 20 pulgadas, localmente menores de [illegible] pulgadas. [illegible] escasa; muy poco cultivo.

24

Nearly Level Plains of Maracaibo Basin: Moderately heavy forest (subhumid)
About 5% cultivated. Rainfall about 25 to 30 inches. Not much erosion.

Llanuras [illegible] Planas de [illegible] de Maracaibo (clima semi-húmedo)
[illegible] que [illegible] del área está bajo cultivo. Las lluvias ascienden a cerca de 25 [illegible] pulgadas. [illegible] existe gran erosión.

25

Nearly Level Plains of Maracaibo Basin: Savanna vegetation (subhumid)
Droughty land. Little used for any purpose. Not much erosion.

Llanuras Casi Planas de la Cuenca de Maracaibo (clima semi-húmedo)
La vegetación es de tipo de sabana. Las tierras son de tendencia a sequias y son poco utilizables. No existe gran erosión.

26

Hilly Benchlands of Maracaibo Basin: Savanna Vegetation (subhumid)
Local sandstone outcrop. Some grazing; no cultivation. Susceptible to erosion.

Tierras Abancaladas en los Cerros de la Cuenca de Maracaibo (clima semi húmedo)
Vegetación del tipo de sabana. Aparecen localmente depósitos de piedra arenosa. Existe alguna ganadería pero no hay cultivos. Con tendencia a erosión.

27

Nearly Level Plains of Maracaibo Basin (very humid)
Much rainforest. Considerable cultivation. Predominantly good agricultural land. Favorable rainfall.

Llanuras Casi Planas de la Cuenca de Maracaibo (clima muy húmedo)
Existen muchos bosques [illegible] así como grandes extensiones en cultivo. En general el área contiene tierras agrícolas. La lluvia es favorable.

Swamp Land
Too wet for cultivation

Ciénegas
Las tierras están demasiado mojadas para dedicarse a cultivo.

LLANOS
LOS LLANOS

28

Llanos: Nearly Level Dominant Type (humid)
Grassed, with scattered trees and clumps of trees. Rainfall ranges from about 40 to 55 inches. Used principally for grazing. No erosion.

Llanos: [illegible] Predominante es casi Plano (clima húmedo)
Cubiertos de pasto natural con árboles y arboledas esparcidas. La lluvia fluctúa entre 40 y 55 pulgadas. Dedicadas principalmente a la ganadería. No existe la erosión.

29

Llanos: Undulating to Rolling (humid)
Mostly forested with light growth. Rainfall about 40 inches. Used chiefly for grazing. Not much erosion.

Llanos: Varios grados de ondulación (clima húmedo)
Estas tierras están cubiertas principalmente de bosques de poco crecimiento y se dedican principalmente a la ganadería. Lluvia de casi 40 pulgadas. No existe gran erosión.

30

Llano Mesas (humid)
Broad, flat, almost treeless plains 10 to 50 feet above the general level of the surrounding Llanos. Rainfall around 30 to 40 inches. Grassland, with very few trees. Used for grazing. No erosion.

Mesas de los Llanos (clima húmedo)
Estos llanos son anchos y planos, a una altura entre 10 y 50 pies sobre el nivel de la planicie circundante, cubiertos de pasto natural y dedicados a la ganadería. Escasean los árboles; la lluvia fluctúa entre 30 y 40 pulgadas. No existe la erosión.

STREAM BOTTOMS AND TERRACES
RIBERAS Y TERRAZAS BAJAS

First Bottoms and Associated Terraces (mostly humid)
Alluvial deposits. Largely in cultivation, especially where lying above prolonged overflow. Rainfall from light to heavy. Considerable irrigation in dry localities.

Riberas Primarias y Terrazas Asociadas (clima mayormente húmedo)
[illegible]

31

Rolling Llanos (humid)
Moderately heavy forest. Good rainfall. Some cultivation. Good agricultural land. Susceptible to erosion.

Llanos Ondulados (clima húmedo)
Estos llanos tienen bosques relativamente tupidos, algunos cultivos y son buenas tierras agrícolas. La lluvia es favorable pero las tierras tienen alguna tendencia a la erosión.